ARCHIVES OF SURGERY

VOLUME 30 JUNE 1935 NUMBER 6

TUMOR OF THE NEUROMYO-ARTERIAL GLOMUS

REPORT OF CASES

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In this article we shall report three cases of tumor of the neuromyo-arterial glomus, an entity as yet undescribed in the American literature, and present a description of this tumor, with a tabulation of all reported cases.

REPORT OF CASES

CASE 1.—E. B., a woman 28 years old, complained of pain in the tip of the third finger of the right hand. This pain began twelve years previously when a drawer was slammed on the finger. Shortly after the accident a blue spot, the size of a pinhead, appeared under the nail at about its center, and the tip of the finger remained painful for many weeks. In the years that followed, slight traumas to the nail caused an exaggerated amount of pain. Also, the finger became rather painful during ordinary cold weather, and if the temperature fell to the freezing point, the pain became almost unbearable, necessitating the wearing of a heavy fleece-lined glove. At times pain appeared spontaneously or possibly after unnoticed slight traumas. Occasionally it radiated up the forearm to the internal condyle of the humerus, following approximately the course of the median nerve. During the two years prior to examination the pain became more severe and the attacks more frequent. The bluish spot remained unchanged, and in all other respects the nail and subungual tissue appeared normal, except that digital pressure on the nail on its ulnar side or pressure on the tip of the finger near the nail caused pain. The pain was more severe during the night.

The patient had consulted several surgeons in order to obtain relief. None had been able to make a diagnosis or even been willing to consider an exploration. A diagnosis of subungual calculus was suggested, but since an x-ray photograph, carefully taken for soft tissue detail, failed to reveal areas of increased density, operation was not advised. When the patient consulted us in July 1933, we noted the following physical signs: Near the center of the finger-nail was an area of bluish discoloration about ⅛ inch (0.32 cm.) in diameter (fig. 1*A*). When pressure was made against the tip of the nail sufficient to cause a blanching of most of the nail, the bluish area was made to stand out in sharper contrast. Gentle pressure applied locally to the region of the discoloration or to the tip of the nail caused pain. There was no irregularity in the growth of the nail, which was well formed and smooth, even under the magnifying glass. No disturbance of circulation or of sensation could be found. The pulp of the finger was normal. Nothing found in the general examination could explain the local pain and tenderness. An x-ray picture showed no abnormality of the bone.

From the Orthopedic Service of Dr. Leo Mayer, Hospital for Joint Diseases.

Two diagnoses were considered: a subungual papilloma and a chronic low-grade infection of the bone with secondary inflammation of the subungual tissues. That we had no inkling of the true nature of the pathologic process was due entirely to our ignorance of glomal tumors, for had we known of Masson's work we could have recognized the condition at a glance.

Fortunately, despite our diagnostic errors, we advised operative exploration, and accordingly the patient was admitted to the Hospital for Joint Diseases in July 1933. Under local anesthesia obtained with 1 per cent procaine hydrochloride, to block the sensory nerves at the base of the finger, the operation was performed as follows:

A portion of the nail was removed piecemeal with a small rongeur, exposing the bluish area visible through the translucent nail. The discoloration seemed to be due to a thinning of the subungual tissues. It extended over an area about ¼ inch (0.64 cm.) long and ⅛ inch (0.32 cm.) wide (fig. 1 *B*). The tissue here looked thin and slightly bluish. When the superficial layer was removed with a knife, a peculiar tissue was exposed which had the appearance of partly fluidified fat. No enveloping capsule was visible. The tissue was gently curetted away until the dorsal surface of the terminal phalanx was exposed. This was found slightly roughened, and a minute crater was noted on its surface. The surface of the bone was gently curetted until all roughening had been removed. The area left by the removal of the fluidified fat was then packed with petrolatum-treated gauze, and a dry dressing was applied.

The postoperative healing of the wound was uneventful, and the nail grew back perfectly. Approximately one week after the operation, the patient complained of spontaneous pains similar to those which she had previously, but in the course of the next few days these disappeared, and since that time she has been free from pain. The cold experienced during the following winter caused no pain, ordinary pressure on the nail causes no tenderness, and no spontaneous attacks have occurred. Severe pressure on the nail still causes slight pain, but this is far less than before and is becoming less with each succeeding month.

Even at the time of the operation we were still in complete ignorance of the true nature of the lesion. We made a tentative diagnosis of subungual chronic infection associated with mild osteitis and had a specimen of the peculiar fatty-like tissue sectioned by the laboratory. To our amazement a report of basal cell carcinoma was returned. This seemed so at variance with the clinical course and symptoms that we requested further pathologic consultation. Prof. James Ewing dispelled our doubts and put us on the right track by informing us that the tissue was neither carcinoma nor chronic infection but a typical glomal tumor.

We are indebted to Dr. H. L. Jaffe, pathologist of the Hospital for Joint Diseases, for the following description of the microscopic appearance of the tumor (fig. 2).

"The section shows sheets of endothelioid or epithelioid-like cells. These cells are fairly large and polyhedral and contain round vesicular nuclei (*A*). All the cells are hyperchromatic. Numerous vascular spaces are observed between the sheets of cells, and these spaces are lined by more flattened cells (*B*). The section also reveals scattered areas containing more or less mucoid neural elements (*C*). The cellular picture displays a general uniformity" (fig. 2).

As no mention of this unusual type of neoplasm had been made in American medical journals, and because our colleagues revealed almost universal ignorance relative to it, a thorough review of the for-

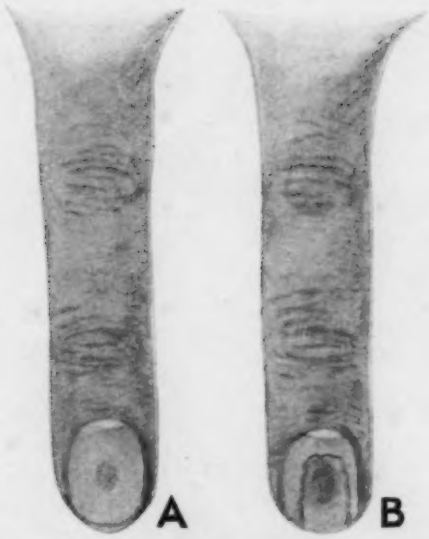

Fig. 1.—The middle finger of patient E. B.: *A*, showing the characteristic appearance of a subungual glomal tumor; *B*, at the time of operation, when a portion of the nail had been removed preparatory to excision of the tumor.

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eign literature was made so that we might present a comprehensive view of the subject.

During the course of our study cases 2 and 3 were brought to our attention. In the first of these Dr. Louis Carp of the Hospital for Joint Diseases operated; in the second, Dr. Milton Friedman of the Newark Beth Israel Hospital.

CASE 2.—R. L., a woman aged 47, was admitted to the Hospital for Joint Diseases on July 17, 1933, in the surgical service of Dr. P. Grausman, with the follow-

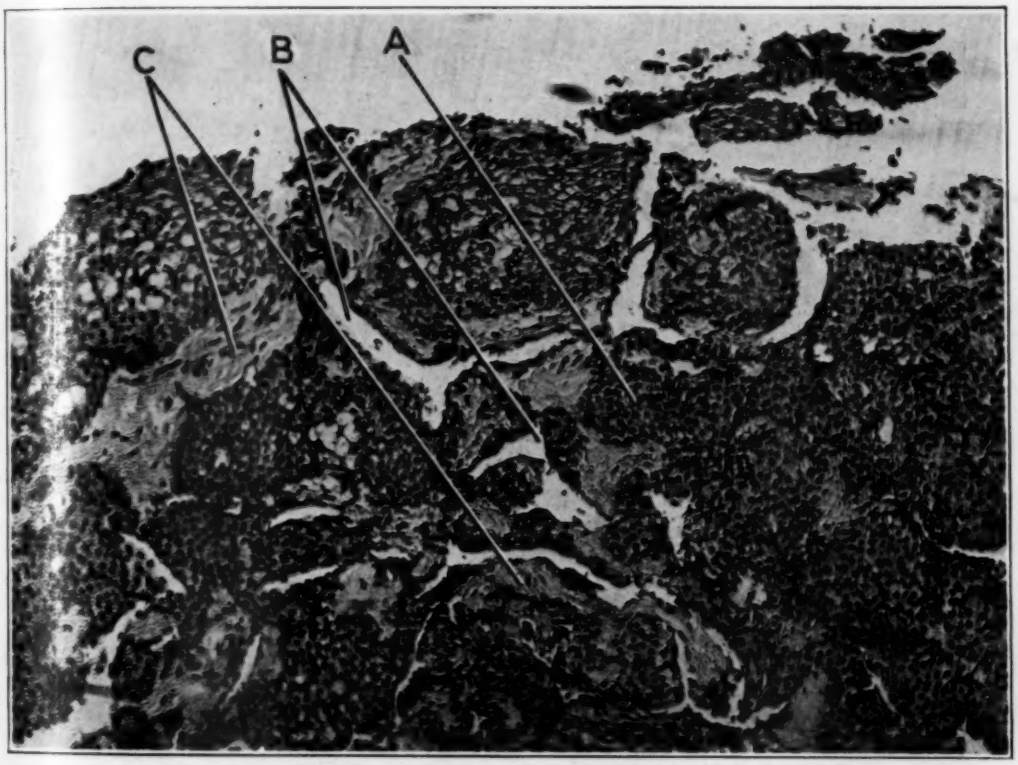

Fig. 2.—Microscopic section of the glomal tumor removed from patient E. B.; × 150: *A*, endothelioid or epithelioid-like cells containing round vesicular nuclei; *B*, vascular spaces lined with flat cells; *C*, mucoid areas representing neural elements of the glomus.

ing complaints: first, a small growth at the tip of the left little finger of eighteen months' duration; second, pain in the left arm, slight for sixteen years, but severe for the past three months. She had had three attacks, each lasting from two to three days, in which pain radiated upward from the finger to the heart and caused a cramplike sensation in that region. There was no history of injury to the finger. The mass had been enlarging very slowly.

On examination, the volar and posterolateral aspects of the base of the terminal phalanx of the left little finger showed a bony-hard swelling the size of a large

pea, apparently attached to the bone. The contour was regular, and the area was tender to touch. Motions of the finger were normal, and there was no adenopathy or other sign of inflammation. The x-ray photograph was normal except for a very slight crater-like defect in the cortex beneath the tumor.

At operation on July 18, a 2 cm. lateral curvilinear incision was made into the distal anterior closed space. Here was found a whitish rounded mass of moderate density, about 1 cm. in diameter, loosely embedded in the hollow of the phalanx, as shown on roentgen examination. The mass was removed by sharp dissection and the incision closed without drainage. Healing was uneventful. The pain disappeared and has not recurred.

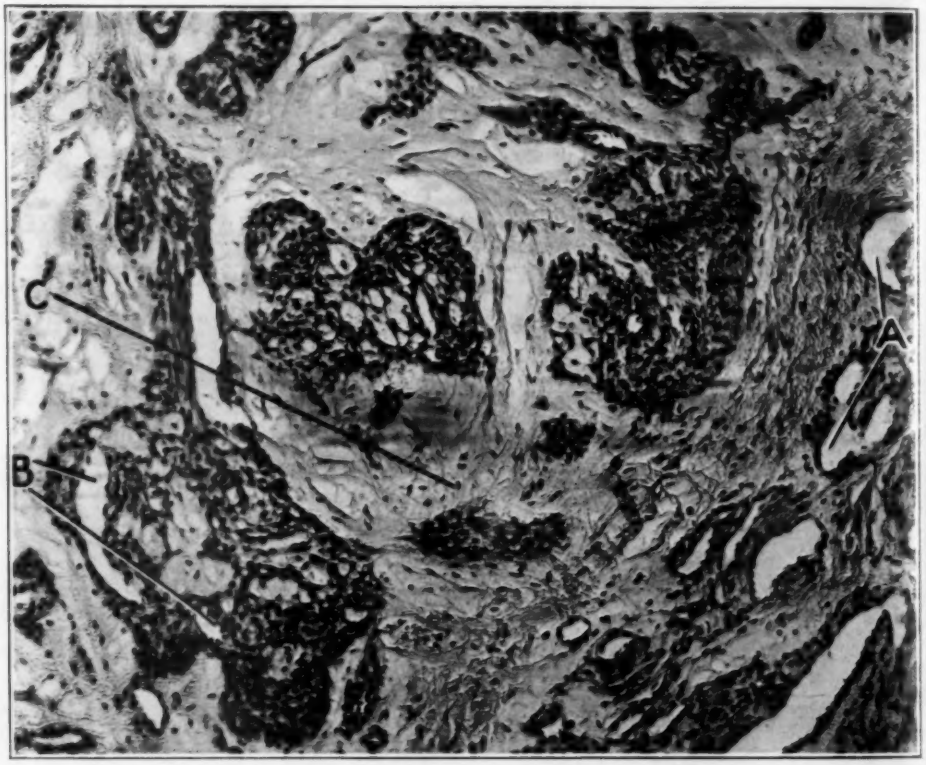

Fig. 3.—Microscopic section of a glomal tumor removed from patient R. L.; × 150: *A*, vascular spaces lined by flattened endothelium; *B*, vascular spaces surrounded by cells with reticular pale blue-staining cytoplasm; *C*, neural elements.

An operative diagnosis of neuroma was made, but the report from the pathologic laboratory indicated that the growth was a typical glomal tumor closely resembling that removed by us two weeks before.

The microscopic report (Dr. Jaffe) was as follows (fig. 3): "There are numerous small vascular spaces. The walls of some of these vascular spaces are made up only of flattened endothelium (*A*), but in other spaces the lining endothelium is surrounded by a layer of cells of varying thickness (*B*). These perivascular cells are of moderate size with reticular pale blue-staining cytoplasm and mostly oval deeply staining nuclei with nucleoli. Between these vascular spaces

there are some areas containing clear, more or less structureless matter. In other areas there is an extremely loosely woven mesh of what appear to be neural elements (*C*)."

Dr. Friedman's patient complained of a tumor of the terminal phalanx of a finger, but unlike the tumors in the first two cases, this was of recent origin and caused no pain.

CASE 3.—C. O., a woman aged 35, noted a small reddish tumor near the tip of the right ring finger, which began bleeding one week after its appearance in April 1933 and continued to bleed intermittently for three months, until she consulted her physician, Dr. Henry Kessler, who referred her to Dr. Friedman. His examination disclosed on the lateral aspect of the tip of the right fourth finger, a red hemangiomatous tumor, 8 mm. in diameter, raised 1 mm. above the line of the skin and extending down into the skin approximately 4 mm. It was not tender. On the surface was a small clot of blood. The border of the tumor was firm, thin, not raised. The results of the physical examination were otherwise negative. The tumor was removed on June 17 by endothermy under local anesthesia. Microscopic examination showed a typical glomal tumor closely resembling the tumors shown in figures 2 and 3. The wound healed without complication, and there has been no recurrence of the tumor.

Tumor of the neuromyo-arterial glomus, to give this tiny entity its full name, was originally described in its present complete form by Masson of Strasbourg, France, in 1924. He based his report on researches and on thorough microscopic studies of the tissues obtained from two subungual tumors presented clinically in 1922, by Barré of Strasbourg. After thorough histologic examination of the tissues, particularly those prepared with his special nerve stains, Masson arrived at the following conclusion: These tumors are benign outgrowths of a structure normally present in the skin and subcutaneous tissue of the entire body. This structure has in all probability been incompletely described under the name of "organ of Ruffini." From the histologic description presented in the following paragraph, he concluded that these structures which he called "neuromyo-arterial glomus bodies" were, as the result of their complicated vascular and neurogenous elements, regulators of the blood supply of the capillaries and arterioles of the skin and thus indirectly regulators of the temperature of the skin. He concluded that the tumors which he had been called on to diagnose were hardly more than enlargements, of the normal glomal bodies, but with greater disorder of the elements, so that their relative proportions varied from case to case.

The following description is a translation from an article on glomal tumors by Hopf of Bern, Switzerland, in which he paraphrases Masson's description of the normal neuromyo-arterial glomus. Owing to its brevity it is given rather than the lengthy original of Masson.

An afferent arteriole carrying blood from the interior of the body forms the major part of the glomus by dividing into from two to four thick-walled branches

with narrow lumens. From two to six vasa efferentia with wide lumens and much blood complete the glomus and unite it to the venous capillaries and veins of the skin. The thickened wall of the afferent arteriolar branches forms the major histologic feature of these bodies. Their lumens are narrow and empty only because of the absence of the "elastica interna," and collapse unless special precautions are taken. The endothelium consists of large cells with homogeneous protoplasm and large nuclei full of chromatin. Next to the endothelium are four or five layers of spindle cells arranged circularly. These cells are short and thick, with oval nuclei. On the periphery of their lightly staining protoplasm are myofibrillae, which are found in greater profusion nearer the endothelium than away from it. This circular layer of muscle fibers forms one half of the thickness of the wall. The other half, not sharply demarcated from it, consists of irregularly placed long pale cells with oval nuclei, and others which are larger and more regular and look like epithelioid cells. The former are thickened opposite the nuclei and send out, as ganglion cells do, protoplasmic projections which often unite on the periphery to compact bundles of fibers, and form a network which encircles the arterioles. They are called nonmyelinated nerve fibers by Masson because they have thin collagenous sheaths and some rodlike nuclei. These fibers are in communication with the much less well constructed network of periarterial sympathetic fibers of the afferent artery. Between the cells which form the wall of the vessel are some very fine collagenous fibers and also a few elastic fibers. The structure of the walls of these vessels is similar to that of a normal artery, but with the characteristic changes due to the local differentiation. The walls of these arterioles form a unified neurovascular system called by Masson the "neuromyo-arterial glomus."

Masson's original article on subungual glomus tumors was followed by the report of two similar cases by Martin and Dechaume in 1925. In 1927, Masson and Gery and Prodanoff widened the location of the lesion by reporting cases in other parts of the body. To the time of the present report twenty-six cases have been described. Grieg of Edinburgh in 1928 pointed out that this new entity probably coincides with the condition known in the older literature as "painful subcutaneous tubercle." Hopf's article in 1930 pointed out a probable similarity of the condition to that in other cases reported in the literature under different names. We have collected all reports of proved cases of glomal tumor and also those we could obtain from the older literature dealing with conditions which, while differently diagnosed, appear to have been similar clinically and pathologically (so far as the pathologic picture is described in the original articles) and appended these to our list as probable instances of glomal tumor.

CASES OF TUMOR PATHOLOGICALLY PROVED TO BE GLOMAL TUMOR

Masson, 1924.—CASE 1.—An 18 year old girl had complained of pain in the left middle finger for five years. The pain occurred several weeks after an injury to the finger-nail when a desk drawer was slammed on it. The pain had gradually become worse and at times was excruciating. It radiated up the arm to the shoulder and then down the body as far as the hip of the same side. There was a constant dull pain, with exacerbations occurring spontaneously and relieved somewhat by cold water. Examination showed a bluish spot under the nail, which was

otherwise normal except for the marked tenderness to pressure. Slight atrophy of the arm and Horner's syndrome on the same side were discovered. Skin tests showed increased warmth and hyperesthesia on the same side. No evidence of a lesion of the central nervous system could be found by spinal tap. A partial section of the sensory nerves to the hand gave only temporary relief. Finally Barré removed the nail, and a pea-sized subungual tumor was discovered and easily removed. Postoperatively the patient had considerable pain for two days and then gradual relief coupled with the disappearance of Horner's syndrome and the sensory changes. Six months later she was completely cured.

Case 2.—A man complained of lancinating pains in his left index finger for thirty years. There was no radiation of the pains nor any history of trauma. The pains were increasing. Exacerbations were produced by cold and relieved by heat, so that the patient had to wear a glove constantly. Examination showed a bluish spot under the nail, and the latter was slightly raised centrally. Encouraged by the first case, Barré removed the nail and discovered a similar pea-sized tumor. Complete relief of the symptoms ensued the day after the operation.

Case 3.—A 23 year old nurse had had increasing pain in the nail of the index finger for six years. The nail was removed sufficiently to enable Barré to excise a subungual tumor, with resultant complete cure.

Martin and Dechaume, 1925.—Case 4.—A 40 year old woman had a small tumor under the nail which lifted the nail somewhat, and which had developed following a slight trauma. Removal of the tumor cured the condition, which has not recurred.

Case 5.—A 70 year old woman had a subungual tumor which developed following slight trauma to the nail twenty-five years previously. There were spontaneous pains and marked tenderness to pressure. Removal produced complete cure.

Masson and Gery, 1927.—These authors were the first to publish a report of cases of glomal tumor outside of the subungual region.

Case 6.—An 82 year old man had had a pea-sized tumor in the subcutaneous tissues of the right thigh for ten years. This caused constant pain which became worse till removal of the tumor produced a complete cure.

Case 7.—A middle-aged man had suffered an injury fifteen years previously, and following this a small tumor developed in the thigh, which caused marked pains. Removal gave complete cure.

Case 8.—In a pathologic collection Masson and Gery found a tumor which had been removed from a 69 year old man.

Case 9.—In a pathologic collection Masson and Gery found a small tumor from the subcutaneous tissue of the forearm.

Prodanoff, 1927.—Case 10.—A 68 year old man had had an injury twenty-two years previously. Nine years later, pains developed in his left thigh, which became constantly worse, so that even the contact of his trousers on the tender area was unbearable. As he walked around he kept his hand in his pocket to prevent contact of the clothes with the skin at that point. At operation a small tumor was found on the inner side of the thigh. It was round, soft, red, 11 mm. in diameter, and its removal was followed by complete cure.

Nicod, 1927.—Case 11.—A 31 year old woman, had suffered pains under the left thumb-nail for four years with no known etiologic factors. The pains were lancinating. The condition was thought to be due to a foreign body, which was probed for but nothing found. The pains were intermittent, but present every

day, radiating up the arm to the shoulder. Neurologists thought that the patient was suffering from a tumor of the spinal cord. Finally a tumor was seen under the nail and removed, with complete cure. The tumor was small, soft and red.

Bonnet, 1927.—CASE 12.—A 46 year old woman had had pains under the nail of the right little finger since the age of 10. The nail was extremely tender. The pains were relieved by cold. They had been severe for many years, during which the patient had had many different types of nonsurgical therapy without relief. The patient was quite willing to have the arm amputated in order to obtain relief. An x-ray photograph showed a slight hollowing of the distal phalanx. At operation the distal phalanx was disarticulated and complete relief obtained. Pathologic examination showed a glomal tumor in the subungual tissue.

Greig, 1928.—CASE 13.—A 42 year old man had had three small nodules in the subcutaneous tissue of the right deltoid region for ten years following an injury. These tumors were painful on pressure and painful spontaneously or when the weather changed. Excision brought about a cure.

CASE 14.—A 33 year old woman had had a nodule in the left calf for eight years, which was tender to pressure, painful when the temperature changed from cold to hot and vice versa, and also painful for about an hour if she stood up after sitting a long while. Excision gave cure.

Lortat-Jacob and Brosse, 1928.—CASE 15.—A 41 year old woman had had pain in the left hand for sixteen years, not following trauma. At first there had been a sensation of tingling; gradually a burning sensation developed which became severe and, though felt in the entire hand, appeared to come from the tip of the fourth finger. Finally, pains developed which radiated up the entire arm. The pains were decreased by immersion of the hand in warm water. Soon a bluish spot appeared under the nail, and from then on there occurred frequent crises of acute pain brought on by pressure on the nail or by cold, so that she was forced to wear a glove constantly. Four years after the onset, the nail was removed to cauterize the bluish spot but to no avail. For three years there had been a slight elevation of the nail, making it more convex. Besides the bluish spot and the convexity of the nail, the findings were negative. Removal of the nail disclosed a subungual tumor, which was removed, with complete relief.

Ianichewski and Lebel, 1928.—CASE 16.—A 50 year old woman had had pains in the left fourth finger for eighteen years, not following any trauma. The pains were increased by cold and dampness and relieved by heat. The finger was extremely tender. The patient was unable to work and walked around wearing a fur glove. A nerve block was attempted, with temporary relief. Examination showed a bluish spot in the palmar aspect of the finger underlying which was a tumor the size of a pea. Its removal produced complete cure.

Hopf, 1930.—CASE 17.—A 50 year old woman had had spontaneous pain over the left acromion for ten years, which increased under pressure, at night and on changes of weather. A subcutaneous tumor, bluish, the size of a pea, could be palpated. This was removed, and complete cure followed.

CASE 18.—A 78 year old woman had had a slowly growing tumor in the palmar aponeurosis for many years, which was not painful, but tender, and bluish. Removal resulted in complete cure.

CASE 19.—A 47 year old man had had a small, slowly growing tumor in the left leg for many years. This was painful and blue. On removal it was soft but sharply defined. Complete cure followed.

CASE 20.—A 65 year old man had had a painful tumor in the thigh for four years. Removal yielded cure.

Picard, 1931.—CASE 21.—A 49 year old merchant had had a slowly growing enlargement of the left index finger just proximal to the nail for a long time. There were no subjective symptoms, no pains. The condition did not follow any trauma. Operation revealed three small tumors. No recurrences were apparent sixteen months later.

Dupont, 1931.—CASE 22.—A woman complained of terrific pains in the upper extremity, and the surgeon, finding a swelling of the finger with osseous lesions on roentgen examination, decided that it was a sarcoma and disarticulated the distal phalanx.

CASE 23.—This was a specimen sent for pathologic examination without any history.

Fernandez and Mousserat, 1931.—CASE 24.—A 38 year old man had complained of pains in both ears for four years, during which time four or five small tumors appeared and disappeared on the helixes of the ears. These tumors were very small, superficial to the cartilage and not attached to it. The pains were spontaneous and also induced by pressure, so that the patient had great difficulty, when going to sleep, in lying in such a way that nothing touched his ears. The pains frequently radiated to the head. Under local anesthesia, the tumors were removed. During the operation much bleeding was encountered. (If it were not for the proved pathologic diagnosis, this condition would appear to be outside of our group of cases, as the tumors were bilateral, appeared and disappeared, and finally, removal was accompanied by much bleeding.)

Costa, 1932.—CASE 25.—A 50 year old woman had had pains in the left upper extremity for over ten years with no traumatic history. Onset occurred with tingling in the left index finger, followed later by pains as though the finger were being pierced by a needle. These lancinating pains then radiated to the shoulder and thorax. They were worse at night. They were also increased by using the hand, by changing its position, by changes of temperature and by pressure on the nail. Cold water gave some relief. Gradually the nail became lifted by a blue-red subungual tumor. There was atrophy of the muscles of the hand and forearm. Neurologic examination gave negative results, but it was difficult to examine the patient because of the extreme pain and tenderness. At operation a tumor, 12 by 5 mm., was removed, with almost immediate relief. Complete cure resulted.

Paulian, Stefan-Popescu and Marinesco-Slatina, 1933.—CASE 26.—A 32 year old woman had been suffering from pains and a burning sensation in the right upper extremity for a long time. These were accompanied by a feeling of warmth on the entire right side of the body and the face. A violaceous spot was found under the right third finger-nail, pressure on which reproduced these sensations. Careful reading of the cutaneous temperatures showed that areas on the right side of the body had temperatures from 1 to 2 degrees higher than those of the corresponding areas on the left side. Removal of the tumor produced cure of all symptoms.

PROBABLE BUT UNPROVED CASES OF GLOMAL TUMOR

Wood, 1812.—Wood discussed cases of "painful subcutaneous tubercles." He stated that these are tumors the size of a pea or coffee bean, found in women in the subcutaneous tissue, not adherent to the skin or deeper tissues, located most usually on the extremities, although they may be anywhere. They all cause paroxysms of pain radiating centrally, are frequently affected by changes of

temperature and are frequently bluish. They may be tender constantly or only during a painful crisis, and their removal is easy and produces complete cure.

CASE 1.—A 30 year old woman had three nodules over the gluteus maximus muscle. Their color was normal. There were frequent attacks of pain in this area brought on by the friction of clothes. Their removal gave complete cure.

CASE 2.—A 70 year old woman had had a tubercle at the right knee for thirteen years which made her miserable with paroxysms of pain lasting from thirty to ninety minutes. During the paroxysms the tumor was tender, but in the intervals it was not. The color was normal. Removal resulted in cure.

CASE 3.—A 28 year old woman had had a tumor on the outer side of the right leg for seven years, with paroxysms of pain during which it became bluish. The pains increased in severity. Removal produced cure.

CASE 4.—A 50 year old woman had had a tubercle in the middle of the right arm for twelve years with pain radiating to the shoulder and down to the fingers. The color was unchanged, but the nodule became tender during the paroxysms. Removal gave cure.

CASE 5.—A 29 year old woman had had a lump over the left gastrocnemius muscle for twelve years which grew slowly and caused shooting pains. Removal cured this condition.

CASE 6.—A 33 year old woman had a tubercle on the left forearm causing exquisite pains, which were relieved by its removal.

CASE 7.—A 57 year old woman had experienced an injury to the right calf ten years previously with resulting formation of a small nodule. This had a reddish tinge and caused pains which were increased by heat or cold. This was not operated on.

CASE 8.—A 40 year old woman had had a tumor at the right elbow for ten years. There were paroxysms of pain during which the tumor became bluish. Removal cured these symptoms.

Paget, 1853.—In his lectures on surgical pathology, Paget described a group of tumors which, despite their size and apparent innocuousness, were remarkable for the pain they caused. He differentiated them from fibrocellular and fibrous tumors by the pain. They were not neuromas. The majority of them were in women and rarely did a patient have more than one. They never grew over ½ inch (1.27 cm.) in diameter, usually lay just below the skin, had a capsule and were not adherent to any other tissues. After removal they never recurred. He referred to Wood's paper as his authority.

Crampton, 1853.—CASE 9.—A 16 year old girl had had frequent attacks of excruciating pain in the tip of the middle finger for three years. Removal of a small tumor, the size of a snipe shot, revealed a fibrous structure with apparently no nerve connection and produced complete cure.

Schuh, 1862.—This author, describing various neoplastic conditions, mentioned a case of a tumor which is called "colloid sarcoma" by Heller:

CASE 10.—A young woman had had pains in the right thumb for many years, increased by weather changes and the slightest touch. The pains radiated up the course of the median nerve. Examination showed a pinhead-sized gray spot under the nail. At operation a pea-sized tumor was removed and complete cure obtained. Clear fluid exuded from the tumor.

Labbé and Legros, 1870.—In discussing neuromas, Labbé and Legros mentioned the following cases:

CASE 11.—A young woman 22 years old had had a tumor on the right calf for three years, with occasional pains at that point. When she became pregnant, the tumor became very painful and very tender on direct pressure. Examination two months later showed a small bluish tumor and its removal cured all symptoms.

CASE 12.—A young woman aged 23 had had a small tumor on the right calf for five years, which became painful three years before examination. The pain increased and radiated to the foot. Removal resulted in cure.

CASE 13.—A 37 year old man had had a little tumor on the right fourth finger for about nine months, causing terrific pain, which radiated up the entire extremity. Examination showed a bluish spot. After removal of the tumor the pain disappeared.

Tillaux, 1870.—CASE 14.—A young woman, aged 25, had a small tumor superficially located in the upper internal quadrant of the right breast, whose cause and duration were unknown. It caused pain in the breast and right upper extremity, preventing her from sleeping and making work difficult. It was slightly tender. Removal resulted in complete cure. Although the author found adenomatous tissue, he diagnosed the growth as painful subcutaneous fibroma.

Kolaczek, 1878.—Writing about an entity known as angiosarcoma, Kolaczek described a tumor as follows:

CASE 15.—A 42 year old woman had had terrific pain under the nail of the right big toe for four years. A soft, gray, pea-sized tumor was removed, producing complete cure. The microscopic reports are very similar to the description of a glomal tumor.

Monod, 1879.—Monod described one of three cases of a condition called by Trilat "painful subcutaneous angioma":

CASE 16.—A 50 year old woman had had a tumor on the back of the right elbow for two years following an injury. The tumor was subcutaneous and not adherent. It was bluish and was very tender. It grew slowly and caused increasing pain, which was worse at night. Removal produced cure. It is stated that it was the pressure of the tumor on the adjacent nerves that caused the pain, as no nerves were found in the tumor.

Chandelux, 1882.—This author presented a paper on his researches into the pathology of "painful subcutaneous tubercles." He stated that these are small painful nodules found under the skin in various parts of the body which have been described innumerable times and given almost as many names. Owing to the fact that various investigators used different stains, they emphasized different factors and therefore called the tumors "fibroma," "neuroma," etc. Bruce and Paget thought that the pain depended on the patient's disposition.

CASE 17.—A 54 year old man had had a pea-sized tumor on the right forearm for twenty-five years with lancinating pain radiating from it, either following pressure or spontaneously. The tumor grew slowly and only to a slight extent. The patient found that strong compression on the entire arm by a bracelet at that level gave relief. There was a reddish discoloration of the skin. Removal resulted in complete cure. The pathology seemed very similar to that of glomal tumor.

CASE 18.—A 43 year old woman had had a small tumor in the right cubital fossa for six years. The pain was terrific and occurred spontaneously or following

pressure. The tumor was felt subcutaneously, and there was a bluish color to the skin. Removal cured the condition. The tumor had a microscopic appearance similar to that in the previous case.

CASE 19.—A 16 year old girl had had pain in the left fourth finger under the nail for two years. The pain gradually became intense, so that the patient could not sleep. The nail was raised slightly. A reddish pea-sized tumor was removed with resultant cure.

CASE 20.—A 46 year old woman had had pains in the right fourth finger in the palmar aspect of its first phalanx for four years. This pain radiated up to the shoulder and down to the abdomen. A pea-sized tumor with no decided color changes was removed, and this cured all the symptoms.

In conclusion, Chandelux expressed the belief that such tumors are painful, not because they are neuromas, but because they compress nerve ends by their growth. They are vascular and therefore cause coloration of the skin, and they have a varied pathology. The spontaneous pains occur when the turgescent vessels expand and press on the nerve endings.

Kraske, 1887.—This author described two subungual tumors and the characteristics of such tumors. They are benign, have a slow growth under the nail, hollow out the underlying distal phalanx, produce a blue discoloration, but have a gray-red color themselves.

CASE 21.—A 42 year old woman had had a pain under the left middle fingernail for twelve years following an injury. There was a blue spot under the nail. The finger was amputated and revealed a gray and red pea-sized subungual tumor, which was not attached to the bone, and which presented a microscopic picture very similar to that of a glomal tumor.

CASE 22.—A woman in the forties had had terrific pain in the left thumb for twenty years. There were marked tenderness to pressure and radiation of pain to the shoulder. A pale pea-sized tumor was easily removed from the subungual region, with complete subsidence of all symptoms by the following morning. The microscopic picture was the same as that in case 21.

Chisholm, 1889.—CASE 23.—A 27 year old woman had had slight twinges of pain in the middle of the third phalanx of the right fourth finger on its ulnar side for fourteen years. This pain was like a toothache; it was increased by excitement, exposure to cold and changes in temperature, but lessened by heat. Menstruation and two pregnancies had increased the pain, but a third pregnancy did not affect it. All treatment had been unavailing and an exploration a failure. Examination showed a tender slight elevation of the skin, of a bluish color. Under tourniquet, Chisholm removed a round body the size of a pea, soft, lying close to the bone but not adherent to it. Removal cured the condition. Prior to operation he had discussed the case with surgeons of the Massachusetts General Hospital in Boston and was advised that they had seen several similar cases, in all of which a small tumor was found at the seat of the pain causing the pain by pressure on nerve endings. Chisholm suggested that the tumor might represent hypertrophy of a pacinian corpuscle.

Müller, 1901.—In discussing eleven cases of tumor of a finger, Müller described a condition called by him "subungual perithelioma":

CASE 24.—A 44 year old woman had injured the nail bed of the right fourth finger twenty-three years previously. A small blue spot formed under the nail and remained there. There were spontaneous pains and also pains caused by changes

of the weather and by dipping the finger into hot or cold water. Examination showed the nail to be slightly lifted, with a blue spot underneath. A small blue-gray tumor was removed which was not attached to the bone and had a microscopic appearance similar to that in the cases described by Kraske, Kolaczek and Schuh.

Batigne and Gaudy, 1901.—These authors described two cases of "fibro-myomatous angioma of the finger":

CASE 25.—A 45 year old man had a small tumor in the middle phalanx of the left fifth finger for six months. It was bluish. The skin was neither adherent to it nor affected. The tumor was removed with ease. It was soft. Rapid healing and complete cure ensued.

CASE 26.—A 25 year old woman had had an enlargement of the palmar surface of the first phalanx of the right fourth finger for five years. There had been a slow steady increase in size. There was slight discomfort on motion of the finger. A tumor was removed with resultant cure.

Lempert, 1905. — Discussing subungual angiosarcoma, Lempert includes Kolaczek's and Kraske's cases with the following:

CASE 27.—A 52 year old woman had had pain under the left third finger-nail for ten years. These pains increased. Every motion of the finger hurt. No trauma was reported. Examination showed the nail to be slightly lifted, with a feeling of slight fluctuation beneath it. There was no discoloration. An x-ray photograph showed slight atrophy of the distal phalanx. At operation a tumor the size of a cherry stone, encapsulated and gray-red was removed, with resultant cure. The same pathologic observations were made as in Kolaczek's case.

Heller, 1927.—Heller discussed subungual tumors, mentioning the cases of glomal tumor described by Masson, in which classification he included one of Kraske's cases. Under the term "angiosarcoma" he included Kolaczek's case, Lempert's case and Kraske's other case, with one reported by König in which there were multiple tumors of the toes with metastases. (The case observed by König is in our opinion not one of glomal tumor.) He calls the condition in Müller's case "perithelioma" and that in Schuh's "colloid sarcoma."

Carstensen, 1927.—Writing on subungual tumors, Carstensen discussed subungual angiosarcoma without being aware of Masson's glomal tumor. She classed her case with Kraske's and Kolaczek's and called them all instances of "perivascular endothelioma."

CASE 28.—A 27 year old woman had had increasing pains in the tip of the right fourth finger for twelve years. These were increased by cold and relieved by heat. Examination showed a bluish red spot under the nail. and the latter was somewhat raised. Removal of the tumor produced complete cure.

Grieg, 1928.—Besides describing two proved cases of glomal tumor, Grieg offers one which was not proved pathologically:

CASE 29.—A 70 year old man had a tumor slightly larger than a pea in the right thigh which was tender and sensitive to changes of temperature. No history of injury was obtained, and no treatment was given.

Hopf, 1930.—Besides reporting several proved cases, Hopf described another case as follows:

CASE 30.—A 65 year old man had had an injury to his left leg forty-eight years ago. A tumor formed, the size of a hazelnut, which was painful for a few months. The pathologic report was that it was not a typical glomal tumor, and Hopf thought that it might be a "transitional type" of glomal tumor.

Eisenklam, 1931.—Discussing subungual tumors, Eisenklam divided them into benign, transitional and malignant groups. Without mentioning glomal tumor, he placed tumors with clinical histories similar to those of glomal tumors in both his transitional and malignant groups. Those with a pathologic diagnosis of sarcoma or carcinoma he placed in the malignant group despite the fact that, as he admits, they are frequently very similar to those in the transitional group.

CASE 31.—A 65 year old man had the nail of his right big toe lifted by a tumor the size of a pea, diagnosed myxoma.

CASE 32.—A 50 year old man had had an injury to his middle finger one year earlier. A blue spot was evident under the nail, and the latter was slightly raised. A tumor was removed from the subungual region, and basal cell carcinoma was diagnosed. There were no metastases, and the patient was fully recovered six months later.

CASE 33.—A 51 year old man had had an injury six months previously. The finger-nail was tender, and there was a blue spot under it. The nail was slightly lifted. Despite the diagnosis of round cell sarcoma, Eisenklam placed this case among those of the transitional group.

DIFFERENTIAL DIAGNOSIS OF GLOMAL TUMOR

Although a positive diagnosis can be made only by microscopic section, the clinical course and symptoms of a glomal tumor are so characteristic that, as a rule, a reasonably certain clinical diagnosis should be made with ease. Only one tumor, the subungual melanoblastoma, may cause difficulty in differentiating a glomal tumor.

If the glomal tumor is not situated beneath the nail, it must be differentiated from the smaller tumors of the skin and subdermal tissues. This is easy with respect to warts, nevi, lipomas, fibromas and small sebaceous cysts. Only with respect to the single small superficial neuroma is there room for doubt. As a rule, however, a neuroma in this situation is multiple, not single, and occurs along the course of the cutaneous nerves.

If the glomal tumor is subungual, it must be distinguished from the following benign growths:

Subungual Exostosis.—This should be bony hard, demonstrable by x-ray photograph and not productive of either lancinating pains or a bluish subungual discoloration. It also occurs more commonly in children and young adults.

Subungual Clavus, or Corn.—This benign tumor may be painful; it occurs at any age of life, and until it grows large enough to protrude beyond the nail it cannot be properly diagnosed. However, it does not cause the bluish discoloration or the excruciating pain.

Subungual Papilloma.—This entity is uncommon. Eisenklam mentioned a 20 year old woman who had a painful warty growth under the nail of the left big toe, which was proved to be a papilloma. Unless this grows large enough to be seen or to elevate the nail markedly,

a differential diagnosis cannot be made except by the absence of the bluish discoloration and the sharp pain.

Subungual Fibroma.—This benign tumor, as reported by Polland and Dubreuilh, occurs on various fingers and toes, distorting them and the involved nails. Eisenklam, however, reported a case in a 26 year old woman, in which an ulcerating tumor pushed off the nail of the big toe and was proved to be fibroma. Again one notes absence of marked pain and bluish discoloration besides presence of a large neoplasm and multiple tumors.

Subungual Enchondroma.—In two cases of multiple enchondroma, as reported by Heller, there were also subungual tumors, but the multiplicity of the tumor provided an easy means of differential diagnosis.

Subungual Angiokeratoma.—Under this heading, Schaumann described a tumor under the nail of the right index finger which had started two and a half years previously. There was a red spot under the nail. The tumor grew until it extended beyond the nail, when a biopsy was performed and the diagnosis made. It was treated and cured by radiation. Thus this rare tumor differentiates itself by its growth and radiosensitivity.

Boeck's Sarcoid.—Haberman presented two cases of subungual Boeck's sarcoid in conjunction with lesions on other parts of the body. The tumor is an ovoid, hard, paronychia-like lump with a blue-red color and causes marked damage to the growth of the nail. The characteristic appearance of Boeck's sarcoid on the skin when viewed through a glass slide pressed on it is duplicated by the appearance as seen through the nail.

Sutton's Tumors.—Sutton reported two cases of tumor at the base of the nail, the definite diagnosis of which he was unable to make. In one case the growth was excised and cure followed; in the other it disappeared on irradiation.

Melanoblastoma.—Of the malignant neoplasms, the most important, both numerically and because of the difficulty of differential diagnosis, is the melanoblastoma. Melanoblastoma is the most common malignant subungual tumor, commencing in the majority of the cases very benignly following a slight injury or infection of the subungual tissue. After a period of from months to five years, ulceration of the subungual tissue occurs with either spontaneous or operative removal of the nail. The wound does not heal, and finally pigmented dots are noted. The growth of the tumor has been slow, and usually by the time a diagnosis is definitely made, metastases have already occurred, so that the prognosis is hopeless. Only three exceptions are reported in which early diagnosis and prompt amputation of the affected digit may have prevented metastases. Prior to the appearance of ulceration and deposits

of black pigment, the tumor frequently is benign looking. Commonly the bluish-black spot seen under the nail resembles somewhat that seen with the glomal tumor. Microscopically there is not the least resemblance between the two tumors.

Sarcoma.—True malignant sarcomas with metastases do occur but very infrequently, if the benign tumors previously incorrectly called "sarcoma" are excluded. Heller cited seven cases of sarcoma with metastases from the literature. Eisenklam reported a case of "round cell sarcoma" in which a 14 year old girl had a painful swelling of the left big toe. This ulcerated and discharged material through a fistulous opening. A pea-sized blue-red tumor was removed from under the nail. Wurmbrund reported a case of chondrosarcoma.

Carcinoma.—Under this heading a case was reported, by Pinheiro-Chagas, of a 60 year old laborer whose big toe had been injured eighteen years earlier. A tumor developed in the nail matrix of the toe; it was proved pathologically to be an epithelioma. Heidingsfeld wrote of a 60 year old man who had had ulcerations at the base of the right thumb-nail for nine years. This area was very tender and the trouble caused incapacitating pains. All treatments had been unsuccessful till Heidingsfeld used radium, with which he obtained complete cure. Under this heading we are including a case reported by Suter of a 39 year old man who had cut his left thumb eight years earlier. Following this the nail began to curl under and grew into the pulp. Later the thumb became swollen and was extremely painful. The swelling and pain were exaggerated when the thumb was crushed in a second accident. The patient entered the hospital with a tumor the size of a hazelnut, for which part of the thumb was amputated. Pathologic examination revealed the tip of the distal phalanx eroded and invaded by tumor cells. Apparently complete cure resulted.

SUMMARY

Three cases of glomal tumor, the first to be recorded in the American literature, are added to the list of twenty-six cases previously reported.[1] This benign tumor, first authentically described by Masson in 1924, develops from a structure normally present in the skin and known as the glomus. It is probably identical with the "painful subcutaneous nodule" reported by Wood in 1812, referred to by Paget in 1853 and

1. Since this article was written, eleven additional cases of glomal tumor have been reported: one by Drs. Mason and Weil (Mason, M. L., and Weil, A.: Tumor of a Subcutaneous Glomus; Tumeur Glomique; Tumeur du Glomus Neuro-Myo-Arterial; Subcutaneous Painful Tubercle; Angio-Myo-Neurome; Subcutaneous Global Tumor, Surg. Gynec. & Obst. **58**:807 [May] 1934) and ten cases reported by Dr. Adair (Adair, F. E.: Glomus Tumor: Clinical Study with Report of 10 Cases, Am. J. Surg. **25**:1 [July] 1934).

described by other authors as "colloid sarcoma" (Heller), "painful subcutaneous fibroma" (Tillaux), "angiosarcoma" (Kolaczek), "painful subcutaneous angioma" (Monod) and "subungual perithelioma" (Müller). Thirty-three instances have been collected by us and reported as "probable but unproved cases of glomal tumor."

The glomal tumor has a characteristic microscopic appearance and a typical clinical course. It is small, usually not more than ½ inch (1.27 cm.) in diameter, of slow growth and long duration. It may be situated in any part of the body, but the favorite site is beneath the nail. There it gives rise to pain of varying intensity and radiation. In the severe cases the pain is agonizing, almost paroxysmal, and radiates upward to the shoulder, even to the heart. When the tumor is not subungual, the pain is usually much less severe. Changes of temperature, particularly cold, increase the severity of the pain. Invariably, the tumor is sensitive to pressure. In some cases it is associated with neurologic or vascular changes such as hyperesthesia and increase in the temperature of the skin. In two cases there was slight atrophy of the entire arm, and in one Horner's syndrome. Examination reveals a pea-sized tender tumor, which, when subungual, has almost always a peculiar bluish tinge showing through the translucent nail. The x-ray picture of the growth in this situation may show a minute crater-like depression of the dorsal cortex of the terminal phalanx.

The only effective treatment is excision by knife or by endothermy. If the tumor is subungual, exposure is secured by removal of a portion of the nail, which in our own case and in many others, regenerated normally. The tumor may be encapsulated as in the majority of cases, or diffuse as in our first patient. No metastases or recurrences after excision have been reported. Invariably pain has disappeared after removal of the tumor.

Glomal tumor is easily differentiated from most of the cutaneous neoplasms. Only two of the latter may cause difficulty: first, the unusual single small neuroma, superficially located; second, the subungual melanoblastoma. This very malignant tumor at one phase of its development is characterized by a bluish-black spot beneath the nail which might be mistaken for a glomus. Operation and microscopic section will at once make the differential diagnosis possible.

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OTOGENOUS ABSCESS OF THE PARIETAL LOBE

REVIEW OF THE LITERATURE AND REPORT OF SIX CASES

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Otogenous abscess of the brain is commonly located in the temporal lobe or cerebellum. This dictum has proved to be true so often that the exceptions to it—cases of abscess in another cerebral lobe—have been almost entirely forgotten or ignored. The more critical reviews concerned with intracranial complications of otitis media refer to individual and often isolated cases of abscess in the frontal, parietal or occipital lobe. Those in the frontal lobe, perhaps because of their greater incidence in this "remote" group, have been given most attention. That these more distant abscesses are not as uncommon as they first appear to be is indicated by their frequency in any large series of cases of otitic abscesses verified at autopsy. This incidence is not absolute, for an increasing percentage of patients with abscess in the temporal lobe or cerebellum are cured by surgical drainage, while abscess elsewhere has been almost uniformly fatal. The percentage is still sufficiently high to warrant a more careful study of these cases than they have received.

No attempt has previously been made to study cases of otogenous abscess in the parietal lobe. Many monographs concerned with abscess of the brain do not even take cognizance of the possibility of such an occurrence. Our experience with 6 examples of parietal localization in a group of 63 cases of otogenous abscess of the brain has led us to believe that more attention should be given to it clinically. In this study an attempt has been made to discover its pathogenesis and characteristic pathology and to note particularly its symptomatology so that the presence of the abscess may be detected more often during life.

REVIEW OF THE LITERATURE

While otogenous abscess of the parietal lobe is without doubt more common than is generally suspected, a review of the literature fails to disclose many examples. A few are reported under significant titles,

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but most of them are included in reviews of the subject of otogenous abscess in general or incidentally in other connections.[1]

1. In this review two sources of error in reporting instances of otitic parietal abscess have come to light. The first, which makes a complete collection of cases well-nigh impossible, is the mistaking of abscess of the parietal lobe for that of the temporal lobe for want of a critical interpretation of the exact site of puncture of the brain in the patients operated on or for want of postmortem study. The second type of error, that of designating as an abscess of the parietal lobe one situated in the frontal or temporal lobe, is discovered when an attempt is made to study the often meager details in the articles listed under this title. A brief review of cases which are reported or cited as cases of abscess of the parietal lobe but which we are inclined to classify otherwise is in order.

In the oft cited case of Hegener (Demonstration zur Lehre vom Hirnabszess, Verhandl. d. deutsch. otol. Gesellsch. **16**:201, 1907), for example, the lesion proved to be primarily an abscess of the centrum beneath the lower portion of the right precentral convolution which also extended caudally to lie partially beneath the postcentral gyrus. The abscess in another case cited in this article (from Manasse's clinic) evidently lay beneath the left superior temporal convolution. In both instances the abscess was associated with thrombosis of the inferior anastomotic vein and was probably secondary to it. While these cases shed considerable light on the pathogenesis of distant otogenous abscess, they cannot be accepted as examples of parietal localization.

The case of Piffl and Pötzl (Ein otogener parietaler Hirnabszess [Rückbildung einer parietalen pseudosensorischen Aphasie], Arch. f. Ohren-, Nasen- u. Kehlkopfh. **112**:93, 1925) is evidently not one of parietal abscess. Their illustration (fig. 1) shows that the region through which the abscess was drained was temporo-occipital. It is likely that the sensory aphasia was due to pressure on the "centers" from below. The patient recovered.

Although Harms' case (Ein geheilter Fall von multipler Hirnabszess-Bildung nach akuter Mittelohreiterung, Ztschr. f. Ohrenh. **72**:118, 1915) was accepted by his contemporaries as an example of otitic parietal abscess, we are inclined to exclude it also. What was thought to be an abscess in the left temporal lobe was first tapped through the mastoid wound and later through another opening in the temporal region. No cultures of the material recovered from the brain or from the mastoid were made. At a third session a puncture made through the temporal opening and directed upward and backward, supposedly into the inferior parietal convolution, resulted in the recovery of about 5 cc. of a clear serous, yellowish fluid. Staphylococcus albus was cultured from this fluid. Even if the fluid was recovered from the parietal lobe, which was very doubtful, it was not characteristic of the contents of a recent abscess. It was more likely fluid collected outside the capsule of the abscess previously tapped.

The case of Ferretti (Su un interessante caso di ascesso cerebrale di origine otitica a decorso eccezionalmente lungo, Arch. ital. di otol. **38**:135, 1927) has also been cited recently as an example of parietal abscess. At autopsy there was found an adhesion of the dura mater to the brain over the right inferior parietal lobule and adjoining portion of the temporal lobe, the residuum of an old subdural infection. Incision of the brain revealed an encapsulated abscess about the size of a walnut which had ruptured into the floor of the inferior horn of the lateral ventricle. While the author was not entirely clear as to the exact location of the abscess, there is nothing in the description to lead one to believe that it was situated within the parietal lobe.

According to Gowers,[2] the parietal lobe is the least common site of otitic abscess of the brain. As late as 1918, Blau[3] found only 2 examples of abscess in a collected series of 352 instances of otogenic abscess of the brain. In a series of 14,534 autopsies, Evans[4] found 194 instances of abscess of the brain, of which 109 (56 per cent) were stated to be consequent to otitis media and mastoiditis. Of this number, 62 abscesses were cerebral and 40 cerebellar, while in 7 instances an abscess was present in both the cerebrum and the cerebellum. Of the 62 cases of cerebral abscess, the temporal lobe was the seat of infection in 56. In 3 cases the abscess was located in the occipital lobe, in 2 in the parietal lobe and in 1 in the frontal lobe.

The first recorded cases that we have been able to discover were reported by Pitt[5] as instances of abscess of the centrum ovale. In 1 case the abscess was apparently secondary to thrombosis of a superficial vein (from the sylvian fissure to the dura), possibly the vena anastomotica superior. In the second case 3 abscesses were found in the hemisphere opposite the infected ear. Moreover, in the lateral sinus adjacent to this ear there was an old thrombus which extended into the posterior half of the superior longitudinal sinus. In both these cases the abscess was discovered at autopsy. In a study of abscess of the brain in infants, Holt[6] reported 2 examples of otitic abscess of the parietal lobe. An infant, aged 6 weeks, died shortly after the onset of bilateral otitis media. A large abscess was found at autopsy; it filled the entire left parietal lobe and extended to the ependyma of the lateral ventricle. In the second case an infant, aged 3 months, had generalized convulsions and died shortly after. A large abscess was found in the right parietal lobe, and there was also an elongated abscess above the corpus callosum on the left side which had ruptured into the lateral ventricle. Pus was found in the left ear. Shortly after the appearance of Holt's study, Westphal[7] described a case of abscess of the left parietal lobe in a woman, aged 34, which was thought to be secondary

2. Gowers, W. F.: A Manual of Diseases of the Nervous System, ed. 2, Philadelphia, P. Blakiston's Son & Co., 1898, vol. 2, p. 475.

3. Blau, L.: Zur Lehre von den otogenen intrakraniellen Erkrankungen. Gehirnabszess-Sinusthrombose-Meningitis, Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres **10**:86, 1918.

4. Evans, William: The Pathology and Aetiology of Brain Abscess, Lancet **1**:1231 (June 6); 1289 (June 13) 1931. Dr. Evans permitted us to use these data in his 2 instances of parietal abscess (table).

5. Pitt, G. N.: Goulstonian Lectures on Some Cerebral Lesions, Brit. M. J. **1**:643 (March 22) 1890.

6. Holt, L. E.: A Report of Five Cases of Abscess of the Brain in Infants, Together with a Summary of Twenty-Seven Collected Cases, Arch. Pediat. **15**: 81 (Feb.) 1898.

7. Westphal, A.: Ueber Gehirnabscesse, Arch. f. Psychiat. **33**:206, 1900.

Data on Collected Cases of Otogenous Abscess of the Parietal Lobe

Author	Case	Age	Sex	Otitis Media	Cerebral sphere	Type of Abscess	Associated Lesions
Pitt	1	?	?	?	?	?	Thrombosis of the superficial cerebral vein (Trolard ?)
	2	8 years	F	Acute	?	Multiple abscesses of the centrum of the opposite hemisphere	Thrombosis of the lateral sinus and the superior longitudinal sinus
Holt	1	6 weeks	F	Acute	Left	Acute, thin-walled	Local meningitis
	2	3 months	F	Acute	Right and left	Not stated	Not stated
Westphal	..	34 years	F	Acute	Left	Encapsulated	Not stated
Harris	..	30 years	F	Chronic	Left	"Recent"	Communicated with an abscess of the left temporal lobe
Lubliner	..	16 years	F	Acute	Left	Not stated	Subdural abscess; abscess of the left temporal lobe
Uchermann	..	?	?	?	?	?	Thrombosis of the lateral sinus
Urbantschitsch	..	35 years	M	Chronic	Left	Multiple small abscesses	Thrombosis of the right lateral sinus; abscess of the right frontal lobe
Coates and Case	..	37 years	M	Chronic	Left	Not stated	Two abscesses (left frontal lobe and left temporal lobe)
Bryan	..	23 years	M	Chronic	Left	Not stated	Subdural abscess; abscess of the left temporal lobe; meningitis
Vibede	..	14 months	M	Acute	Right	Evidently recent	Thrombosis of the right lateral and superior longitudinal sinuses and the right superior cerebral veins
Evans	1	6 months	F	Acute	Left	Large, thin-walled involving the adjacent lobes	Meningitis; internal hydrocephalus; thrombosis of the right inferior cerebral vein, right middle cerebral vein and right lateral sinus
	2	15 years	M	Acute	Left	Fairly large, thin-walled	Thrombosis of the left lateral sinus; extensive softening of the brain
Ginsburg	..	?	?	?	Left (?)	Not stated	Thrombosis of the right lateral sinus (?); subdural abscess (?)
Fraser	..	15 years	M	Chronic	Right	Not stated	Basilar meningitis; mural thrombus in the left lateral sinus (surgical diagnosis)
Collins	..	?	?	Chronic	Right	Not stated	Abscesses also found in the left frontal and temporal lobes
Faunce and Shambaugh	..	10 years	M	Acute	Right	Encapsulated	Thrombosis of the right lateral sinus, right superior petrosal sinus, right inferior cerebral vein and right minor anastomotic vein; abscess of the right occipital lobe
Courville and Nielsen	1	45 years	M	Chronic	Left	Large circumscribed	Adhesion of the tegmen, dura and brain on the left
	2	10 months	M	Acute	Left	Early	Edematous brain
	3	37 years	M	Chronic	Right	Large, recent	Thrombosis of the right lateral sinus; subdural abscess on the right side
	4	32 years	M	Acute ?	Right	Large, poorly encapsulated	Meningitis
	5	2½ years	F	Acute	Left	Small, encapsulated (surgical intervention)	Recovery; no known complications
	6	8 years	F	Acute	Right	Large, thin-walled	Softening of the surrounding brain

to a pelvic infection. However, during life bilateral otitis media was found to be present. The onset of the cerebral lesion was manifested two and one-half months before death by epileptiform seizures followed by aphasia and right hemiplegia. At autopsy an encapsulated abscess was found.

The case described by Harris [8] was unique and typical of a group of otogenous abscesses of the parietal lobe secondary to those in other parts of the brain. A recurrent attack of otitis media in an adult, aged 30, resulted in generalized convulsions and death. At autopsy there was found an adjacent abscess in the temporal lobe with a "stalk" leading to an erosion of the tegmen. This abscess was connected by a fistulous tract with another in the parietal lobe. Lubliner [9] reported a similar case, an abscess in the parietal lobe being considered secondary to one in the temporal lobe. A subdural abscess had previously been drained at the time of operation.[10] The case reported by Coates and Case [11] also belongs to this group. The abscess which they found in the parietal lobe was evidently an extension from one of two abscesses in the frontal lobe of the left side. A discolored, softened area in the white substance of the left temporal lobe indicated a more recent abscess in this situation.

In another interesting group of cases the parietal abscess is associated with thrombosis of the venous channels, particularly of the lateral sinus. As in the previous group, other abscesses may be found in the ipsilateral or even in the contralateral hemisphere. Uchermann [12] described an abscess associated with thrombosis of the lateral sinus of the same side;

8. Harris, T. J.: Pathologic Findings of the Intra-Cranial Complications of Middle Ear Disease, Laryngoscope **15**:535 (July) 1905.

9. Lubliner: Monatschr. f. Ohrenh. **49**:25, 1913.

10. In these two instances the description of the cerebral lesion was too meager to permit one to gain any accurate concept as to the course of the infection as it passed from the temporal to the parietal lobe. In coronal sections of the brain in this region it is found that the two lobes, save in their most caudal portions, are separated by the rather deep sylvian fissure. Infection extending from the temporal to the parietal lobe must either cross this fissure or go by way of the rather narrow external capsule, a most unlikely development. If the fissure is crossed, there will be necessarily a preliminary meningocerebral adhesion uniting the opposed surfaces of the lobes in the fissure. Infection would then pass through this sealed-off area much as it does from the tegmen into the basilar surface to form the original temporal abscess. In these unusual cases, the brain should be given more critical study, for these cases shed a great deal of light on the many unsolved problems of otitic intracranial complications.

11. Coates, G. M., and Case, A. E.: Multiple Brain Abscesses Following Otitis Media, Ann. Otol., Rhin. & Laryng. **33**:335 (June) 1924.

12. Uchermann, V.: Otogene Hirnabscesse im Frontallappen und im Parietallappen, Monatschr. f. Ohrenh. **49**:561, 1914.

both the abscess and the thrombosis were otitic in origin. In the case reported by Urbantschitsch [13] multiple small abscesses were found in the left parietal lobe, with a larger one in the right frontal lobe. A chronically affected right ear was also complicated by thrombosis of the right lateral sinus. One of the cases of Pitt, already referred to, belongs to this group. In both of Evans' cases [4] there was found a thrombosis of the lateral sinus. In 1 of these the middle and inferior cerebral veins were also occluded. In this case the abscess was situated in the opposite parietal lobe. The recently reported case of Faunce and Shambaugh [14] is of interest in that two abscesses, one in the right inferior parietal region and the other in the parieto-occipital region, were associated with thrombosis of the right lateral and right superior petrosal sinuses and of the cortical veins of the regional dorsolateral surface of the hemisphere. The lesions were secondary to a transitory otitis media.

Thrombosis of the lateral sinus is not always present, however, in cases of multiple abscesses. For example, in Bryan's [15] case one abscess, which had been drained surgically, was situated in the left parietal lobe and a second was found at autopsy in the left temporal lobe. A subdural abscess was also found in the middle fossa on the left side.[15a]

A review of the available literature, therefore, leads one to conclude that, though rare, otogenous abscess of the parietal lobe does occur and that in many instances it has been mistaken, so far as location is concerned, for abscess in the temporal, the frontal or the occipital lobe.

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13. Urbantschitsch, E.: Kontralaterale Hirnabscesse, Monatschr. f. Ohrenh. **52**:50, 1918.

14. Faunce, C. B., and Shambaugh, G. E., Jr.: Abscess of the Brain Following Mild Transitory Otitis Media, Arch. Otolaryng. **17**:673 (May) 1933.

15. Bryan, J. H.: Abscess of the Brain of Otitic Origin, Ann. Otol., Rhin. & Laryng. **37**:819 (Sept.) 1928.

15a. In a more recent general survey of the literature on intracranial complications of otitis media, we found three additional references to parietal abscess. Ginsburg (Otogene Hirnabscesse nach den Beobachtungen der oto-laryngologischen Klinik in Dnjepropetrowsk, abstr., Zentralbl. f. Hals-, Nasen- u. Ohrenh. **18**:236, 1932) found 1 contralateral parietal abscess in 11 cases of otogenous abscess of the brain. The details of the clinical history or autopsy observations were not given. In Vibede's case (Tilfaelde af otogen hjaernabsces, Hospitalstid. **67**:33, 1924), a parietal abscess on the right side was found at autopsy, evidently due to retrograde extension from the right lateral and the superior longitudinal sinus into the superior cerebral veins, draining the parietal lobe. In Fraser's case (Sigmoid Sinus Thrombosis (L.); Metastatic Parietal Lobe Abscess; Death, J. Laryng. & Otol. **48**:274 [April] 1933) a right parietal abscess was found at autopsy. During life a mural thrombus was removed surgically from the left lateral sinus. Before death, marked weakness and loss of sensation were noted in the left arm and leg. In discussing Fraser's case, Collins recalled having seen a case of multiple abscess of the brain evidently secondary to chronic otitis media on the right side. One abscess was located in the right parietal lobe, another in the left frontal lobe and still another in the left temporal lobe. These cases are included in the table.

The parietal abscess may be one of two or more in one or both cerebral hemispheres, suggesting a vascular spread of infection. The occurrence of an associated thrombosis of the lateral sinus or of the connecting venous channels indicates that the route of infection is by the venous rather than the arterial route. The essential details of reported cases are included in the accompanying table.

REPORT OF CASES

As is so often the case, the history of our experience with otitic parietal abscess began with a diagnostic failure followed promptly by a therapeutic disaster. To be sure, the clinical symptoms were somewhat unusual for an abscess of the temporal lobe, which was originally suspected. The difficulty in establishing the existence of a predisposing infection in the middle ear, however, served to deflect our attention from the conspicuous motor and sensory manifestations. The postmortem disclosure of a large circumscribed abscess within the parietal centrum served to emphasize the meaning of these symptoms, a lesson which served us in good stead when the next patient came under our observation. In the meantime, a review of a large series of records of postmortem examinations revealed 3 additional cases. A short note on the 3 cases found in the records of the department of pathology precedes the reports on the 2 cases which came to our attention clinically. We also had an opportunity (case 6) to study a specimen brought to the laboratory in which a parietal abscess was found.

CASE 1.—*Chronic left otitis media and mastoiditis in a man. Death following mastoidectomy. Autopsy. A large circumscribed abscess in the left parietal lobe.*

An emaciated Mexican man, aged 45, died on July 25, 1918, following a mastoidectomy. He had been admitted on July 18, 1918, to the Los Angeles County General Hospital, but no further information was available, the clinical record having been destroyed.

At autopsy a recent surgical wound was found in the left mastoid region. On removal of the calvarium the dura was found to be tense and hyperemic. The cerebral cortex was also hyperemic. At the base of the left temporal lobe the brain and dura and in turn the dura and bone of the tegmen tympani were found to be firmly adherent to each other. When the brain was sectioned, a large, well circumscribed abscess filled with thick green pus was found to occupy the centrum of the left parietal lobe. The left temporal bone was carious and honey-combed with abscesses. The causative organism was not identified.

Comment.—The emaciation of the patient, the complete delineation of the abscess and the firm local adhesions speak for a chronic infection. It was of interest to find the classic prerequisites of a temporal abscess —adhesion of the dura to the bone and to the brain—but the development of a parietal infection. A complete clinical history would have been most desirable in a study of this case.

CASE 2.—*Death of an infant with signs of bronchopneumonia. Autopsy. Bilateral otitis media. Softening of the cerebral cortex in the left parietal region which proved to be infarction with early formation of abscess.*

A Mexican boy, aged 10 months, was admitted to the Los Angeles County General Hospital in a moribund state on Nov. 19, 1930, and died within three hours. No history was obtained at the time other than that the child had been acutely ill with a fever for three days. The child was cyanotic, dyspneic and lethargic.

At autopsy the brain was found to be edematous. The meninges showed no gross change. The cerebral cortex was found to be softened in the left parietal region. Sections taken from this area for microscopic examination revealed an extensive infarction of the cortex and underlying white matter. With the exception of the nuclei of the neuroglia the cellular elements were not demonstrated by routine staining methods. In several situations within this infarcted area there were accumulations of leukocytes. Polymorphonuclear cells predominated in the center of each collection of cells, while lymphocytes formed an irregular peripheral zone. They were especially conspicuous in the form of "cuffs" in the spaces about the regional blood vessels. A mucopurulent exudate was found in each middle ear, being most abundant in the right ear. Bilateral bronchopneumonia was also present. A pneumococcus was the infecting organism.

Comment.—The clinical record of this case is unfortunately incomplete. Every effort has been made, even after an interval of years, to secure a more detailed history of the child's illness, but without success. It would have been particularly enlightening to know whether or not convulsions, particularly the jacksonian variety, occurred.

CASE 3.—*Recurrent right otitis media with mastoiditis. Necrosis of the tegmen antri. Surgical drainage of the subdural abscess through the temporal route. Death after five days. Autopsy disclosed a right parietal abscess and thrombosis of the right lateral sinus.*

A Mexican man, aged 37, was admitted to the Los Angeles County General Hospital on March 23, 1934, with a history of recurrent attacks of otitis media on the right for many years. He complained of headaches and pain in the right ear and appeared extremely ill. At times he was definitely irrational. There was definite tenderness on pressure over the right mastoid. The temperature was somewhat subnormal, and the pulse was found to be slowed (from 64 to 68) on several occasions. Roentgenograms revealed an increased density of both mastoids (sclerosis) with some possible rarefaction on the right in the region of the genu of the lateral sinus. A white blood cell count revealed 20,600 leukocytes per cubic millimeter, 90 per cent of which were polymorphonuclears.

On later examination a definite weakness of the left arm, leg and left lower region of the face was found. The eyegrounds were reported to be normal.

Mastoidectomy on the right was performed on March 25 by Dr. Isaac Jones, who found necrosis of the bone forming the tegmen antri and the posterior wall of the external auditory canal. Granulation tissue covered the dura above the tegmen. It seemed evident that a cerebral abscess existed, and a trephine opening was made in the right temporal region by Dr. Carl W. Rand. On opening the dura, a large amount of greenish-yellow pus welled up into the wound. Several drains were placed in the subdural space and the wound closed. Culture of the pus from the mastoid and subdural space revealed that the offending organism was a pneumococcus.

The patient did poorly following the operation. The next morning he had several generalized convulsions and was noisy and talkative. He was unable to swallow. The temperature remained about normal, and the pulse rate varied between 70 and 112 per minute. A Cheyne-Stokes type of respiration developed, and the patient died on March 30, after an abrupt rise of temperature to 106 F.

At autopsy the right lateral sinus was found to be completely thrombosed, as were the venous channels in the parietal region. This surface of the hemisphere was covered with thick green pus which also adhered to the inner surface of the dura. There was a fistulous opening in the dura over the tegmen antri which extended into the operative excavation in the mastoid bone.

In the centrum of the right parietal lobe there was a large, softened, necrotic area which had a dark green color; it was evidently a very early abscess. This area did not communicate with the ventricular system. There was no gross evidence of involvement of the temporal lobe.

Comment.—This case presents several points of interest. The presence of thrombosis of the lateral sinus suggests a possible etiologic relationship between this lesion and the abscess, especially since the venous channels in the parietal region were also occluded. It is also possible but not likely that the parietal abscess was secondary to the subdural abscess which covered the dorsolateral surface of this hemisphere. The abscess was obviously a very recent one.

CASE 4.—*Transient otitis media on the right in an adult. Development of left hemiplegia, headache and stupor. Surgical exploration with tapping of the abscess high in the centrum of the right cerebral hemisphere. Death from septic meningitis. Autopsy.*[16]

A white man, aged 32, was admitted to the neurologic service of the Los Angeles County General Hospital on Jan. 1, 1930, with the complaint of headache for five or six weeks and weakness of the left side for four weeks. The patient's wife stated that the patient had had a severe cold in the head six weeks before, its appearance being followed shortly by a purulent discharge from the right ear and generalized throbbing headaches. The minor discharge ceased spontaneously after two or three weeks. A week after the onset of otitis media, the patient noticed paresthesia and numbness beginning in the left leg and extending upward to the left arm. Following these sensory manifestations the affected members felt "dead." Progressive left hemiplegia then developed, associated with increasingly severe headaches. The patient described several fainting spells; when we questioned his wife we learned that these were attacks of generalized convulsions.

Examination on admission revealed a somewhat inattentive and at times drowsy man who presented conjugate deviation of the head and eyes toward the right and well marked spastic left hemiplegia and hemihypesthesia. The pupils were unequal, the right being smaller than the left. Both reacted somewhat poorly to light. The nasal half of the right optic disk was blurred. There was slight rigidity of the neck, but the Kernig sign was not elicited. The deep reflexes were exaggerated on the left and associated with a bilateral Babinski sign, which was more marked on the left. The cremasteric reflex was absent on the left.

Lumbar puncture revealed a clear spinal fluid under increased pressure, but otherwise normal. The white blood cell count was 14,250 cells per cubic milli-

16. This case has been reported in brief by Meyers (Conjugate Deviation of the Head and Eyes, Arch. Otolaryng. **13**:683 [May] 1931) in another connection.

meter, of which 77 per cent were polymorphonuclears. Roentgenograms of the skull revealed an increase in density in the mastoid portion of the right temporal bone.

Under ether anesthesia, exploration of the brain was made on Jan. 7, 1930, by Dr. George H. Patterson. A trephine opening was made over the right ear, somewhat higher than usual for an exploration of the temporal lobe. Repeated punctures in the temporal lobe failed to reveal an abscess. An abscess at a depth of 5 cm. was tapped by an oblique puncture upward and slightly backward toward the parietal lobe. An abundance of greenish-yellow pus was recovered, from which a pneumococcus was cultured.

The patient promptly recovered from his stuporous state and had temporary relief from his headaches. His improvement was short-lived, however, for a gradually rising temperature and symptoms of meningeal irritation soon made their appearance. A lumbar puncture revealed a cloudy spinal fluid, and pneumococci were found on smear and culture. He died on January 14, 1930.

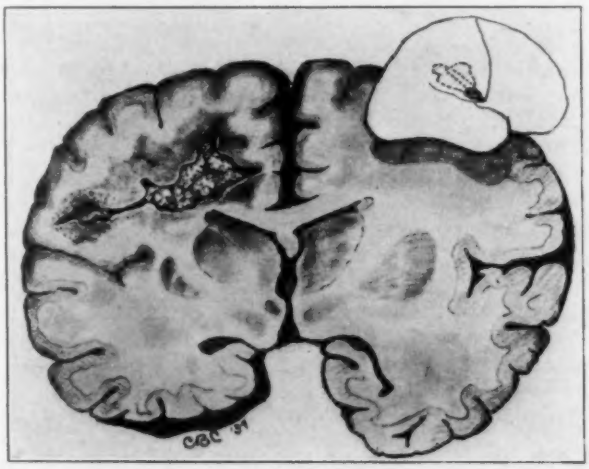

Fig. 1 (case 4).—Drawing of a coronal section of the brain, showing the abscess in the right parietal lobe. The insert shows the location of the abscess and the position of the drain.

Autopsy, performed sixteen hours post mortem by Dr. William R. Dodson, resident pathologist, disclosed extensive meningitis with greenish fibrinopurulent exudate most abundant over the right hemisphere and at the base of the brain. The brain was hardened and examined subsequently in the laboratory of neuropathology. The rubber catheter drain emerging from the lower end of the postcentral gyrus was still in place. The drain extended upward, mediad and backward into a large, irregular, circumscribed but poorly encapsulated abscess occupying the right parietal centrum (fig. 1).

Comment.—This patient was at first suspected of having an intracranial tumor, a history of otitis media not having been elicited. When the patient became comatose and surgical intervention seemed urgent, a review of the history with his wife recalled to her the drainage from the right ear for two or three weeks at the beginning of the symptoms.

This made the diagnosis of abscess a definite probability. The occurrence of contralateral hemiplegia, the significance of which was not then understood, suggested a lesion higher and deeper in the hemisphere than the usual abscess of the temporal lobe.

The lesson which this patient's case taught had not been entirely forgotten when the next patient with similar symptoms and course, even though they were in a different setting, came under observation. The marked motor manifestations were the conspicuous and characteristic signs.

CASE 5.—*Bilateral otitis media following scarlet fever. Onset of jacksonian convulsions and right hemiparesis. Gradual recovery. Recurrence of hemiparesis after spells of vomiting two months later. Development of an irritable lethargic state. Negative exploration of the left temporal lobe. Later exploration and drainage of the left parietal lobe abscess. Recovery with residual jacksonian seizures.*[17]

A girl, aged 2½ years, was admitted to the Los Angeles County General Hospital on Dec. 4, 1931, with obvious scarlet fever of four days' duration. Four days later bilateral otitis media developed, and bilateral myringotomy revealed a purulent exudate in both middle ears. On December 23 a high temperature developed, and vomiting and jacksonian convulsions on the right side with conjugate deviation of the head and eyes to the right made their appearance. In the stuporous state which followed, right hemiplegia was noted. The spinal fluid was found to be bloody and under increased pressure. Because of cloudiness of both mastoids in the roentgenogram, bilateral mastoidectomy was done by Dr. Andrew Love. The uncovered dura was found to be normal in every respect. Culture of pus from the mastoid revealed Streptococcus haemolyticus. On the following day the child had roused somewhat but was aphasic and hemiparetic. The mastoidectomy wounds healed promptly, the paresis gradually improved and by the time of the patient's discharge on Jan. 30, 1932, she had apparently entirely recovered.

Because of the periodic bouts of vomiting and the difficulty in getting the child to take her food, her mother brought her to the hospital on February 24. After a period of observation the patient was found to be increasingly irritable and lethargic, and the optic disks gave evidence of increasing intracranial pressure. On the presumed diagnosis of abscess, the left temporal lobe was explored above and behind the ear on March 3 by one of us (Dr. Courville). The dura was found to be somewhat thinned, and the brain was under some pressure, but on repeated probings of the lobe the instrument failed to encounter either an abscess or the inferior horn of the ventricle.

The child seemed somewhat improved after recovery from the anesthetic. However, minor chills were noticed on two occasions, and spells of vomiting recurred. Three weeks later, because of increasing irritability and stupor, another exploration was decided on. A new opening was made farther forward toward the tip of the temporal lobe, and the brain was again explored with a needle. The tip of the inferior horn was entered, and the 3 or 4 cc. of slightly yellowish fluid which was recovered promptly coagulated. With the history of the previous case

17. This case has been presented in another connection in which was stressed the otitic etiology in certain instances of infantile hemiplegia (Concerning Certain Cerebral Manifestations Following Acute Otitis Media in Infancy and Early Childhood, Am. J. Dis. Child. **49**:1 [Jan.] 1935). In this connection, repetition of clinical facts will be avoided, and certain surgical aspects will be emphasized.

in mind, the surgeon was prompted to explore the parietal lobe. A trephine opening revealed a very thin, transparent dura, evidently under considerable pressure. When the dura was opened a small knuckle of cortical tissue promptly herniated itself. The exploring needle encountered a heavily encapsulated abscess about 3 cm. beneath the cortex. A rubber tube drain was anchored in place. The nonfetid and greenish-yellow pus proved to be sterile. Figure 2 indicates the location of the three scars incident to the three explorations.

The child promptly recovered, and after three weeks the drain was removed. Repeated examinations revealed a residual weakness and clumsiness of the right extremities with persistent pathologic reflexes. There was some degree of mental

Fig. 2 (case 5).—Photograph showing three scars in the scalp over trephine openings in the skull. The dotted line shows the location and extent of each incision. The abscess was tapped through an opening over the parietal lobe. The scar of the original mastoidectomy incision is hidden by the auricula.

impairment, and the patient was unable to use formed words as before. She was discharged from the hospital on May 22.

On September 20 the child was brought in for reexamination, at which time the mother stated that there was some residual weakness in the right arm and leg, especially noticeable when the patient was tired. She had been rather wilful and difficult to control. There was some mental retardation, and the patient was still unable to talk. Three weeks later she was again brought in for examination with the report that she was having convulsive seizures affecting the right arm, apparently preceded by some painful or otherwise unpleasant sensations in this

member. The seizures continued for a number of months and were still present eighteen months after operation. Repeated examinations revealed evidences of a minor motor weakness in the right arm with characteristic reflex changes. She was reexamined on April 27, 1934, two years after drainage of the abscess. Some difficulty in talking was still present, and minor attacks of pain in the right arm were noted occasionally. Persistent pathologic reflexes were also noted on the right.

Comment.—This case represents the culmination of a series of experiences pertaining particularly to the pathology of otitic parietal abscess. It has led us to believe that a diagnosis of this lesion can be made at times and surgical treatment successfully instituted when conditions are favorable.

Our last experience was concerned with the postmortem findings in a case of otogenous parietal abscess. The record of this case was furnished through the courtesy of the attending physician.

CASE 6.—*Transient otitis media in a child three years before present illness. Headaches during the morning for two years. Onset of convulsions, left hemiplegia and coma. Death.*

A schoolgirl, aged 8 years, was first seen by Dr. Ben Anderson on March 13, 1934. The physician was called because the child had a convulsion following which she became stuporous. An inquiry into her history disclosed the fact that she had always been a semi-invalid because of a congenital pathologic condition of the heart. Three years before bilateral otitis media had developed following an attack of influenza, from which she recovered without incident after four weeks. For the past two years she had complained of headaches in the morning associated with ptosis of the right eyelid, both of which conditions improved as the day progressed. In the latter part of February 1934 she had an infection of the upper respiratory tract with fever, which persisted for several days. On March 8 she had a "spasm" and vomited, remaining in bed for the day. On March 12 she again became ill, complaining of severe headache in the right temporal region and ptosis of the right eyelid, associated with pain in the right eye.

Doctor Anderson found that the girl was semistuporous. The right eyelids were swollen and red. The right pupil was dilated. There were loud to-and-fro murmurs heard everywhere over the thorax but loudest over the base of the heart. The heart rate was irregular. The cyanosis and clubbed fingers were further indicative of a congenital cardiac lesion. There was complete left hemiplegia. The neck was rigid. A diagnosis of right parietal lobe abscess was made.

Lumbar puncture revealed a clear, colorless fluid under marked increase in pressure. There were 32 cells per cubic millimeter. There was no increase in globulin or sugar.

The child did poorly, and headaches, nausea and vomiting made their appearance. Convulsions recurred with periods of stupor. A few days before death the right eye became prominent, and Cheyne-Stokes respiration developed, associated with spasms of extensor rigidity. The right pupil was widely dilated, and the right disk was markedly swollen.

The patient was seen in consultation a few hours before death by Dr. Carl W. Rand, who found her in coma and having spasms of decerebrate rigidity. She died on March 27.

Autopsy was performed on the day of the patient's death by Doctor Anderson. As was suspected, a congenital lesion in the form of a defect in the intraventricular septum was found. The partially hardened right cerebral hemisphere was brought to this laboratory for study. The convolutions of this hemisphere were considerably flattened, particularly in the posterior parietal region. The superficial cerebral veins were markedly engorged but not thrombosed. In this region the cortex had been broken in the process of removing the brain from the skull. This had resulted in a rupture of the abscess and evacuation of its contents. This area appeared to be pale, and in it the small cortical vessels were empty. Beneath the torn cortex was found a thin-walled, empty capsule of an abscess. Its superficial portion was adherent to the overlying cortex beneath the terminal portion of several veins. The location and extent of the abscess and the appearance of its capsule are shown in figure 3.

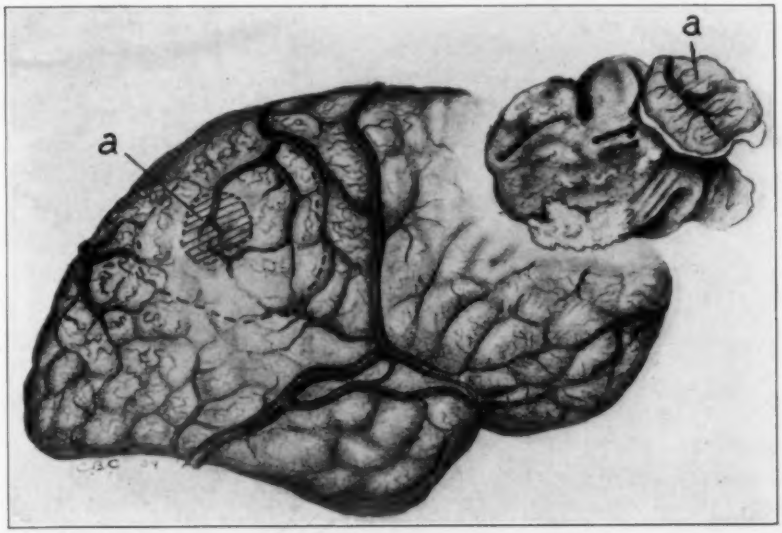

Fig. 3 (case 6).—Drawing of the brain, showing the appearance of the cortex in the parietal region. The shaded area (*a*) indicates the portion of the cortex attached to the capsule. The location of the abscess is indicated by the dotted line. The insert shows the collapsed capsule of the abscess.

Comment.—This unusual case did not come under our clinical observation, although it was our privilege to examine the brain and the contained abscess. From the long history of headaches during the morning and ptosis of the right lid, it is likely that the abscess resulted from the transient acute otitis media from which the patient had suffered three years before. This seems to be further proved by the fact that there had been no otitis media or other possible etiologic factor in the interim.

PATHOGENESIS

Since no previous effort has been made to study the group of otogenous abscesses of the parietal lobe as a whole, the pathogenesis

has not been elaborated on. A clue to the situation has been found in cases in which thrombosis of the lateral sinus is also present, a matter already dealt with in another connection.[17] As in the case of abscesses in other situations, there are a number of etiologic possibilities which must be considered (fig. 4). An otogenous parietal abscess may be secondary to: (1) an otogenous subdural abscess, (2) osteomyelitis of the parietal bone (which in turn is secondary to infection within the squamous portion of the temporal bone), (3) an otitic abscess in the temporal or frontal lobe or (4) thrombosis of the venous channels or

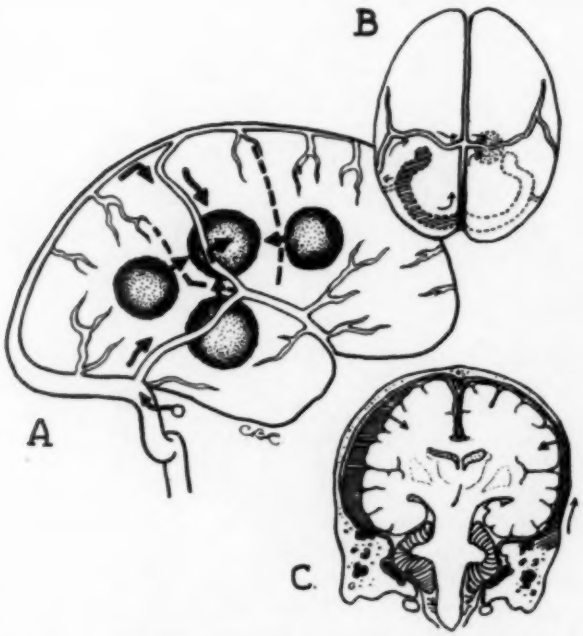

Fig. 4.—Drawing showing the possible pathways of infection from the middle ear to the parietal lobe. *A* illustrates the development of the parietal abscess by extension along the venous channels or the development secondary to the otitic abscess in the other lobes; *B*, an insert, shows the possible pathways of a parietal abscess in the hemisphere opposite the draining ear, although such an abscess may be due to an apparently unaffected ear on the same side, and *C*, an insert, shows the situations which may theoretically result in a parietal abscess—a subdural abscess on the left and osteomyelitis of the squama of the temporal and the parietal bones on the right.

extension along these channels without grossly visible thrombus formation.

The possible development of a parietal abscess from an extension into the brain of infection from an overlying subdural abscess must be considered, particularly since this lesion has been found to be present in

a number of the cases. On rare occasions it is found that an abscess secondary to empyema of the frontal sinuses is located at some distance from the point of invasion of the intracranial space. Examination of the brain in these cases reveals an extensive obliteration of the subdural space, evidently due to a resolved subdural infection, perhaps of low grade virulence. While the same possibility must be admitted in this connection, no clearcut case has yet been described. In the group of cases reported in the literature a subdural abscess was found in 2 (Lubliner [9] and Bryan [15]). It was also present in 1 of our cases (case 3). While proof either for or against this conception would be difficult to find, it seems to us unlikely that intracerebral abscess results from acute subdural abscess. In the last analysis it is more likely a question of coincident lesions having the same source.

It is also possible that osteomyelitis of the parietal bone secondary to an otogenous infection in the squamous portion of the temporal bone might result in the formation of a parietal abscess. Local adhesion to the leptomeninges in the parietal region would pave the way for invasion of the brain substance. The situation is a most unusual one, and it is not likely that many cases of parietal abscess will be accounted for on this basis. No such example has been reported in the literature.

The development of a parietal abscess secondary to one located in either the temporal or the frontal lobe is a matter of rare chance. Such an abscess in reality is one of several cavities of a multilocular abscess and communicates by a fistulous tract with the parent abscess. It is usually the result of a secondary extension through a weakened spot in the capsule of the original abscess. Lubliner [9] reported a unique case in which an otitic abscess in the left temporal lobe was drained surgically. A recurrence of symptoms brought about the patient's death. At autopsy it was found that the first abscess communicated with a second located above the sylvian fissure by means of a fistulous channel. Coates and Case [11] reported a somewhat similar case in which an otogenous abscess of the frontal lobe communicated with another cavity in the parietal lobe.[10]

It is obvious that abscesses developing in any of the foregoing ways are pathologic rarities and occur as a matter of chance. Invasion by way of vascular channels seems to explain the occurrence of the greater number of them.

The proposition that these distant abscesses are the result of spread of infection by way of the arterial tree has met with considerable favor in some circles. This requires as a preliminary step either (*a*) the development of a periarterial infection, secondary arteritis and extension into the lumen of the carotid artery or (*b*) an invasion of the venous channels of the middle ear and extension into the lateral sinus, resulting

in a systemic infection. The relative rarity of pericarotid infection and the fact that such an infection causing either arteritis or thrombosis practically never results in the formation of a cerebral abscess seems to rule out the first possibility. Furthermore, the absence of typical septic manifestations and of other localized foci elsewhere in the body and the frequent occurrence of a solitary cerebral abscess under the circumstances seriously controvert the second conception.

On the other hand, there is convincing evidence at hand to indicate that extension occurs, in many cases at least, by venous channels. A possible mechanism is suggested by the occurrence at times of cerebral symptoms in cases of thrombosis of the lateral sinus. These manifestations are presumed to be due to a stasis in the inferior anastomotic and occipital veins and their communicating vessels.[18] When the parietal abscess occurs in a case in which there is a continuous thrombosis from the lateral sinus into the inferior cerebral or communicating veins leading to the parietal region, the mechanism of the spread of infection is obvious.

Furthermore, when there has been thrombosis of the venous network of the dorsolateral surface of the brain without involvement of the lateral sinus or, on the other hand, of the lateral sinus without involvement of the veins, the likelihood of extension even in the presence of a break in the chain of the thrombosed vessels must still be granted. This possibility still exists when the venous system is not found to be grossly involved at autopsy. It is our belief that a small thrombus responsible for localization of the infection may resolve, while the infection in the brain substance goes on to the formation of an abscess. The various degrees of involvement of the venous channels as illustrated by the reported cases is shown in figure 5.

The actual method of production of the abscess following venous thrombosis is not entirely clear. Hlaváček [19] predicated a perivenous infarct as the mechanism which might produce under suitable circum-

18. This conception is substantiated by clinical evidence which also suggests that there is some relationship between thrombosis of the lateral sinus and the occurrence of manifestations in the parietal lobe. This question has recently been studied by Bodechtel and Richter (Ueber Scheitellappensymptome beim otogener Thrombophlebitis der Gegenseite, Ztschr. f. Hals-, Nasen- u. Ohrenh. **32**:505, 1913). The presence of symptoms referable to the central region in these instances suggests that obstruction of the venous flow into the lateral sinus from this region, particularly in the presence of an infectious condition, is accompanied by a disturbance in the circulation (edema). If more critical neurologic examinations were made in all cases of thrombosis of the lateral sinus, minor evidences of this disturbance would frequently be found. This has been the experience of the writers.

19. Hlaváček, V.: Časop. lék. česk. **2**:1041 (July 11) 1930; cited by Eagleton, W. P.: Arch. Otolaryng. **16**:228 (Aug.) 1932.

stances an abscess on the one hand or meningitis on the other. It is likely that either a focus of red softening occurs which becomes infected or a primary focus of infection develops in the subcortical white substance along an afferent vein. The occurrence of a variety of lesions and of different anatomic types of abscess suggests that invasion may take place in one of several ways.

The pathogenesis of multiple abscesses is of particular interest. The occurrence of multiple foci has been accepted by many as presumptive

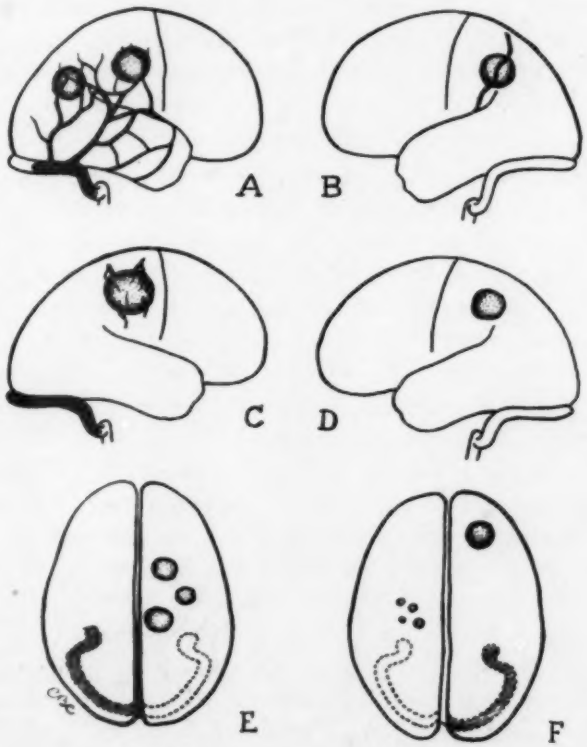

Fig. 5.—Drawing showing the relationship of thrombosis of the venous channels to abscess of the parietal lobe, as illustrated by lesions found in various cases. *A* (case of Faunce and Shambaugh [14]) illustrates thrombosis of the right lateral sinus and the afferent veins; *B* (case of Pitt [5]), thrombosis of the superficial cerebral vein (probably the vena anastomotica major); *C* (case 3 of our series), thrombosis of the right lateral sinus and the veins over the abscess (in the latter situation thrombosis was possibly due to the underlying infection); *D* (case of Westphal), thrombosis which did not affect any of the venous channels (verified by autopsy); *E* (second case of Pitt), thrombosis of the contralateral (left) lateral sinus and posterior portion of the superior longitudinal sinus and multiple abscesses of the centrum ovale; *F* (case of Urbantschitsch [13]), thrombosis of the contralateral (right) lateral sinus, multiple small abscesses of the left parietal lobe and solitary abscess of the right frontal lobe.

evidence of their metastatic (arterial) origin. According to the evidence at hand, this is not necessarily true. In the case of Faunce and Shambaugh [14] this is obviously not the case, for the 2 abscesses in the parieto-occipital region were located immediately beneath the network of thrombosed superficial veins. We believe that in many instances of multiple abscess there may be no gross residual evidence of involvement of the venous channels. When an abscess formation in the temporal lobe is one of multiple abscesses, it may be due to extension by contiguity rather than by way of the venous channels. Thus two distinct modes of spread may be present in a single case. While it is not certain, this may have been the situation in Bryan's case.[15] In 1 of our cases (case 3) there was a local fistula in the tegmen, dura and brain but a subdural rather than a temporal abscess.

PATHOLOGY

A study of the histologic characteristics of otogenous abscess of the parietal lobe is not of paramount interest in this connection, since they are much the same as those of abscess in other situations. Certain deductions may be drawn, however, from the morbid anatomy, which sheds light on the problem of cerebral abscess as a whole.

The anatomic types of abscess found in the parietal lobe are the same as those that occur elsewhere. The large acute abscess, otherwise known as purulent encephalitis, with its poorly defined margins and necrotic center, is exemplified by case 3 of our series. In later stages of this same anatomic variety, suppuration occurs in the central portion of the involved region, and its walls are ragged, necrotic and stained at times with hemorrhage. The surrounding cerebral tissue is edematous, swollen and infiltrated with pus. It is this type of abscess which has a short clinical course and is evidently the result of invasion of a virulent organism against which the body has little resistance.

The more slowly developing, circumscribed but poorly encapsulated abscess is usually unilocular, with sharply defined walls. The surrounding zone of encephalitis varies in width with the acuteness of the process. In this type, the thinness of the wall of connective tissue is due, in part at least, to the large size of the cavity and not alone to the low resistance against the infection. Cases 2 and 4 are examples of this anatomic type. This variety of abscess yields a large amount of pus when tapped at operation, and if drainage is properly instituted a cure may be attained, at times with certain residual manifestations. When the abscess is not drained the patient often succumbs with respiratory failure, death being due to the greatly increased intracranial pressure. The history in case 6 suggests that these abscesses, though large, may acquire a capsule and remain partially quiescent for months and even years.

The classic small, heavily encapsulated abscess may occur here as typically as in the temporal lobe. The cavity is usually small or of moderate size. Theoretically, an abscess of the parietal lobe may be multiloculated, as may one in the temporal lobe, but no case of this type has been described.[20] The thick capsule is usually an indication of a more chronic and avirulent infection in a circumscribed focus. This type of abscess, perhaps the most favorable for surgical treatment, may be drained as successfully when located in the parietal as when located in the temporal lobe, provided it is uncomplicated. This seems to be proved by our experience in case 5 of this series.

Perhaps the most important conclusion to be drawn from the fact that any anatomic variety of abscess may occur in the parietal lobe is that the type of abscess does not depend on the method by which the infection reaches the brain. This may be concluded from the fact that abscesses in the temporal lobe are for the most part due to contiguous infection of the bone, dura and brain, while those of the parietal lobe are commonly the result of vascular extension. It is therefore likely that the anatomic type of otogenous abscess produced is the result of the virulence and number of invading organisms or is of the nature of a presumed preliminary (vascular) lesion which becomes secondarily infected. It is possible that both factors play a variable rôle.

As has already been indicated in a review of the literature, an abscess of the parietal lobe may constitute one of a group of multilocular abscesses, being connected by means of a fistulous tract with other cavities in the temporal or frontal lobe (Harris,[8] Lubliner[9] and Coates and Case[11]). In such instances the clinical picture is complicated and almost impossible to evaluate properly. In the case of Urbantschitsch[13] one group of small abscesses was found in the left parietal lobe while another larger abscess was found in the left frontal lobe. The case of Faunce and Shambaugh[14] is of interest in that two abscesses (one parietal and the other parieto-occipital) had their origin in an extensive thrombosis of the dorsolateral venous system. In the cases forming our series, no case of multiple abscess was disclosed.

As one might suspect from the origin of the abscess, adherence of the capsule to the altered overlying cortex is at times observed. This was illustrated in our sixth case. The infection arising from local venous thrombosis extends through the altered cortex, and the resulting reaction of the connective tissue binds the capsule to the pia and its vessels.

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20. The case of Urbantschitsch[13] is of interest in that there were several small abscesses in the left parietal lobe and another larger one in the right frontal lobe. The description furnished by this observer was too meager to ascertain whether the abscesses were distinct cavities or whether they were multiple loculations of a single focus of infection. One would infer that the former was the case.

As in instances of abscess of the temporal lobe, rupture into the lateral ventricle may occur. In this case the abscess must break through the intermingled fibers of the corona radiata to burst into the lateral margin of the body of the ventricle or through the corpus callosum to break through its roof. In one of Holt's [6] cases rupture into the ventricle had taken place, and in the other the abscess extended to the ependymal lining but gross rupture had not occurred. In Bryan's [15] case the temporal abscess had ruptured into the ventricle while the abscess in the parietal lobe had not. There was no instance of rupture into the ventricle in our series.

The changes in the surrounding brain as a result of the presence of the abscess are of interest. The overlying convolutions are found to be flattened and the lobe enlarged, as is the case with an abscess in any situation. Streaks of exudate are frequently found along the vessels of the cortex overlying the abscess, a finding not so commonly observed in cases of abscess of the temporal lobe.

The overlying vessels are at times thrombosed. This is of particular significance in this connection, for in many instances the thrombosed veins are part of a widespread involvement of the venous system of the dorsolateral surface (Faunce and Shambaugh [14]), of some isolated vessel (Pitt [5]) or of the lateral sinus (Pitt,[5] Uchermann,[12] Urbantschitsch [13] and case 3 of this series). At times the opposite lateral sinus or its afferent vessels are found to be thrombosed (the second case of Evans [4] and the second case of Pitt [5]). The significance of thrombosis of the venous channels has been discussed in the previous section.

A subdural abscess has been found to be present in a number of instances. This lesion was disclosed at a previous operation in Lubliner's case [9] and in case 3 of our series and at autopsy in Bryan's case.[15] The subdural collection of pus is probably a coincident lesion, arising separately from the original infection in the middle ear or secondary to thrombosis of the lateral sinus.[21] It is rarely due to rupture of a cerebral abscess through the adherent leptomeninges into the subdural space. This has not occurred in any of the reported instances of otogenous abscess of the parietal lobe.

CLINICAL ASPECTS OF OTOGENOUS ABSCESS OF THE PARIETAL LOBE

As the result of our experience in dealing with vascular or infectious lesions of the dorsolateral surface of the hemisphere we have come to

21. The matter of otogenous subdural abscess is one of unusual interest. Following thrombosis of the lateral sinus it may be found in a variety of situations. The question has been briefly discussed in a previous communication (Fatal Complications of Otitis Media, with Particular Reference to the Intracranial Lesions in a Series of Ten Thousand Autopsies, Arch. Otolaryng. **19**:451 [April] 1934), and a more detailed study is made the subject of a forthcoming review.

believe that their diagnosis constitutes a neurologic problem capable of solution. From a therapeutic standpoint an accurate localizing diagnosis is essential to successful drainage of the abscess. Should such an abscess be tapped by chance through a high temporal trephine opening, the angle which the tube assumes makes continuous drainage unlikely or dislocates it from its original position in the abscess cavity. Furthermore, it may so lacerate the brain tissue that drainage occurs about the tube with a resultant septic meningitis. If, on the other hand, one can approach the abscess through a trephine opening directly over it, the matter of drainages becomes a more simple problem, provided, of course, the abscess is encapsulated or at least circumscribed.

It is evident that the symptoms produced by an expanding lesion differ considerably from those of a purely local and destructive one. An abscess situated within the limits of the parietal lobe may, as a result of pressure, consequent edema or actual extension, so disturb the function of adjoining regions as to result in symptoms referable to these areas.[22]

We shall therefore find it necessary in cases of parietal abscess to consider some symptoms which have long been attributed to other cortical areas. Needless to say, the limitations of the subject at hand preclude a complete discussion of the symptomatology of lesions of the parietal lobe. We shall confine ourselves, therefore, to the essentials which are of value in the diagnosis of parietal abscess. Unfortunately, in almost all of the reported cases the situation of the lesion was misinterpreted or the case report so brief that one is unable to draw any conclusions as to their neurologic symptomatology.

The irritative motor symptoms are characteristically jacksonian seizures affecting the contralateral side of the body but particularly the upper extremity and face. These symptoms are at times observed in infants and young children with otitis media, and in most instances recovery is complete. Whether or not the occurrence of these symptoms signifies the development of an abscess can be determined only

22. The wide variety of otogenous lesions, whether toxic, vascular or inflammatory, which affect the dorsolateral surface of the brain are probably the result of an extension of the noxious agent along venous channels from the middle ear.[17] The location and extent of the ultimate lesion are due in part to the pattern of the venous channels draining this area. The inferior anastomotic vein, which serves as the connecting link between the venous radicals draining the middle ear and the dorsolateral venous system, may empty into the superficial middle cerebral vein at any point along its course. This exposes to the influence of the noxious agent the posterior surface of the frontal as well as the parietal lobe. The marked motor as well as sensory manifestations so often present in these cases suggest that this area is actually affected. From a clinicopathologic point of view it seems best to designate this area as paracentral, although it is not to be confused with the paracentral lobule on the medial surface of the hemisphere.

by watching carefully the clinical course of the illness. In the first known reported cases of Pitt [5] typical jacksonian seizures were described. In a recent contribution on cerebral abscess Atkinson [23] stated that jacksonian seizures are characteristic of lesions of the parietal lobe. Unfortunately in the earlier cases in our series complete clinical histories were not available, so it could not be ascertained whether the symptoms occurred. The first patient (case 4) to come to our attention was said to have had convulsions of a generalized character with subsequent deviation of the head and eyes and contralateral hemiplegia. One patient (case 5) had characteristic contralateral jacksonian seizures with involvement particularly of the arm and face.

Conjugate deviation of the head and eyes as a symptom of lesions of the posterior and inferior portion of the parietal lobe was first described by Landouzy [24] in 1879 and has been confirmed many times since. It was the subject of a recent contribution by Meyers [16] from the Los Angeles County General Hospital. When deviation occurs as a part of the seizure, the head and eyes are directed toward the convulsing members and away from the side of the lesion (case 5). Later, when paralysis has set in, the deviation is toward the side of the lesion (case 4). In either case deviation may be of so minor a degree as to be overlooked or may be absent altogether.

Paralytic motor phenomena made their appearance in all of the cases which were observed personally but have not been recorded in most of the reported cases. No doubt minor manifestations of weakness have been overlooked in young children or in adults in a terminal state. In case 3 weakness was observed only by chance just before surgical exploration. In case 4 it developed after "generalized" convulsions and was associated with conjugate deviation of the head and eyes toward the side of the lesion and away from the paralyzed members. In case 5, that of a child aged 2½ years, the right jacksonian seizures observed at the onset were followed by right hemiplegia, most marked in the arm and face. These manifestations slowly disappeared but reappeared when signs of pressure became evident. This suggests that motor symptoms are due to irritation or pressure on the precentral gyrus. In case 6 preterminal contralateral hemiplegia was noted.

Sensory disturbances have long been recognized as primary parietal manifestations. The postcentral and perhaps adjacent cortex integrate the various sensory impressions from the opposite side of the body and

23. Atkinson, E. M.: Abscess of the Brain; Its Pathology, Diagnosis and Treatment, Lancet **1**:486 (March 10) 1928.

24. Landouzy, L.: De la déviation conjuguée des yeux et de la rotation de la tête, etc., Bull. Soc. anat. de Paris **4**:293 (April 18) 1879; cited by Charcot, J. M., and Pitres, A.: Etude critique et clinique de la doctrine des localisations motrices, Paris, Germer, Baillière et Cie, 1883.

fuse them into a whole whereby a person is able by touch to recognize the size, shape, weight and texture of objects placed in his hand. In this function the proprioceptive sense probably plays a leading rôle.[25] In the lesions of the parietal lobe, the patient experiences a decreased sensibility for all modalities without loss of any except tactile discrimination (astereognosis). In case 4 there was a history of paresthesia and numbness of the left extremities, beginning in the foot, if the record is correct. On examination there was hyperesthesia of the entire left side of the body. Because of mental torpor and decreased sensibility, a true estimate of stereognosis could not be reached. In case 5 because of the patient's age (2½ years) sensory changes could not be detected. Later, however, the appearance of minor seizures on the right side seemed to be heralded by sensory manifestations. The child would grasp the right arm and cry out in distress before the motor manifestations became apparent.

Trophic changes in the form of atrophy of the muscles of the contralateral extremities from parietal lesions in early life have been described by von Monakow.[26] This observation has been made recently by Silverstein[27] in a case of tumor of the parietal lobe. Most patients with parietal abscess do not survive long enough to enable one to determine whether or not atrophy occurs. In case 5 it had not occurred in the limbs affected during the acute stage of the abscess as late as two years after successful surgical drainage.

Vasomotor disturbances have also been described by von Monakow in cases of lesions of the parietal lobe. It is of interest to note that in 1 of our cases the skin of the contralateral side was warmer to touch and that perspiration was obviously increased on that side. It is possible that these manifestations are not in themselves evidences of parietal dysfunction.

Hemianopia has been described by various observers in instances of parietal lesions. In cases of tumor or abscess of the parietal region it is easily possible that the subjacent optic radiation is influenced by pressure or extension. This manifestation has not been observed in any of our cases.

Disturbances of speech in cases of lesions of the cortex or subcortex of the parietal lobe constitute too large a subject for detailed discussion in this connection. Mind blindness, alexia, agraphia, apraxia

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25. Kramer, F.: Die korticale Tastlähmung, Monatschr. f. Psychiat. u. Neurol. **19**:129, 1906.

26. von Monakow, C.: Gehirnpathologie, Vienna, Alfred Hölder, 1905, p. 683.

27. Silverstein, A.: A Tumor of the Parietal Lobe Showing Jacksonian Sensory Seizures Involving the Tongue, Face, Thumb and Index Fingers with Advanced Premature Atrophy of the Affected Parts, J. Nerv. & Ment. Dis. **77**:371 (April) 1933.

and disorientation have all been described. The size and exact situation of an abscess and the extent of involvement of surrounding cerebral tissue by encephalitis or edema have much to do with the manifestations presented.

Of the various possibilities the one of particular interest is that of mind blindness, a subject introduced by Munk after a study of experimental cortical lesions in dogs. This has been greatly elaborated on by Pötzl.[28] A person so affected is able to see clearly but fails to recognize even the most familiar faces and objects. He is therefore disoriented and helpless. He necessarily has sensory apraxia, for he fails to recognize the use of objects which he cannot identify. Thomas [29] reported a case in which the patient "forgot" the affected extremities. A true paralysis did not exist, but the patient did not use the affected extremities because he was unaware of their presence. This manifestation, not observed in any of our cases, can be distinguished from paralysis if one calls the patient's attention to these members and asks him to move them. Amnesic aphasia, affecting most often and most seriously the memory for names, is quite a common finding in association with lesions of the inferior parietal lobule.

Disturbance of consciousness is a common manifestation of cerebral abscess usually attributed to increased intracranial pressure. However, in cases of lesions of the parietal lobe, repeated periods of unconsciousness have been described. We have not been able to determine whether this is any more true of parietal than of temporal abscess. It would be a difficult matter to settle this question when the parietal lesion is an abscess, since fluctuations in the degree of consciousness are a common accompaniment of abscess of the brain in any situation.

SUMMARY

The parietal lobe has been said to be the most unusual location for an abscess secondary to otitis media. A review of the literature would seem to substantiate this claim, although many abscesses in this situation have been miscalled as far as location is concerned.

A series of 6 cases has come to our attention. Three of these were discovered in a review of 10,000 records made at autopsy. Two other cases were studied clinically as well; 1 terminated fatally after exploration and in the other a correct diagnosis was made and the abscess was successfully drained. In the last case, a study was made of the brain, which was brought to our laboratory by the attending physician, who also furnished us with the clinical history.

28. Pötzl, O.: Die Aphasielehre vom Standpunkte der klinischen Psychiatrie, Leipzig, Franz Deuticke, 1928, vol. 1.

29. Thomas, cited without reference by Claude, H.: Maladies du système nerveux, ed. 2, Paris, J. B. Baillière et fils, 1932, p. 435.

The distance between the middle ear and the parietal lobe predicates in most instances a vascular route for the transmission of the infection. The arterial route has been quite widely accepted as the one of choice. The frequent association of thrombosis of the lateral sinus and of other associated venous channels has led us to believe that invasion occurs by this route instead. Infection enters the venous radicals draining the middle ear and, with or without gross occlusion of the veins, extends to the parietal or other regions.

The same anatomic type of abscess may occur in the parietal as in the temporal lobe, i. e., (1) acute diffuse abscess, (2) large circumscribed abscess and (3) small encapsulated abscess. The vascular and other inflammatory lesions secondary to otitis media may occur here as well as in other parts of the brain.

Otogenous abscess of the parietal lobe is frequently associated with one or two or more cerebral abscesses, which results in a complex clinical picture. It is at times associated with subdural abscess. In most of the reported cases the abscess has occurred on the left side of the brain.

The characteristic symptoms of abscess of the parietal lobe thus far determined are jacksonian seizures affecting the contralateral members, often associated with deviation of the head toward the convulsing members, followed by monoplegia brachiofacialis, deviation away from the paralyzed side, sensory manifestations and at times aphasia.

The incompleteness of the knowledge of the pathologic and clinical picture calls for a more critical study of every potential case and a careful examination of the system of connected venous channels of the brain should the case terminate fatally. More complete clinical records in such instances are necessary.

DIAGNOSIS OF NEUROGENIC LESIONS OF THE URINARY BLADDER BY CYSTOMETRY

AN APPRAISAL OF THE METHOD BASED ON EXPERIMENTATION WITH ANIMALS

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In clinical urology Rose and his co-workers [1] made studies of the urinary bladder by means of the cystometer, an instrument which records synchronously the intracystic capacity and pressure. The results seemed to indicate that valuable diagnostic criteria with respect to neurogenic lesions of the bladder could be obtained in this manner. These investigators classified neurogenic dysfunctions of the bladder cystometrically into those caused by (1) irritation or destruction of the sympathetic, (2) irritation or destruction of the parasympathetic, (3) interference with the function of the nervus pudendus, (4) lesions of the central nervous system above the origin of the thoracolumbar (second dorsal) spinal segment, (5) psychic (hysterical) bladder, (6) reflex mechanism seen in cases of postoperative retention and (7) intraspinal or extraspinal injury provided the lesion affects one of the reflex areas of innervation of the bladder.

In general, cystometric curves were interpreted as representing parasympathetic or sympathetic overbalance if abnormal pressure and capacity were encountered. In the case of a destructive lesion of the sympathetic (1 in the classification) one expected to find abnormally low intracystic capacity and unusually high intracystic pressure. In the case of a destructive lesion of the parasympathetic (section 2 in the classification) the reverse effects were expected. Irritative lesions, on the other hand, were presumed to produce an imbalance simply as a result of the overstimulation of one side or the other of the autonomic

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1. (*a*) Rose, D. K.: Cystometric Bladder Pressure Determinations: Their Clinical Importance, J. Urol. **17**:487 (May) 1927. (*b*) Rose, D. K., and Deakin, R.: A Cystometric Study of the Pharmacology of the Bladder, Surg., Gynec. & Obst. **46**:221 (Feb.) 1928; (*c*) The Cystometric Diagnosis of Central Nervous System Syphilis: A New Appreciation of the Term Neurogenic Bladder, Am. J. Syph. **13**:3 (July) 1929. (*d*) Rose, D. K.: Clinical Application of Bladder Physiology, J. Urol. **26**:91 (July) 1931. (*e*) Rose, D. K., and Rollins, P. R.: Pyelonephritis in Pregnancy: Its Treatment and Prevention Based on Cystometric Conclusions, J. A. M. A. **96**:231 (Jan. 24) 1931.

system, and the effects observed cystometrically were believed to reflect this disturbance by varying the capacity and pressure within the bladder. Other factors not of neurogenic origin, however, entered into the final analysis of cystometric records, particularly the coexistence of such pathologic conditions as obstruction of the neck of the bladder, urethritis, cystitis and cystocele.

McCaughan, Major and Braasch [2] reported a group of eighty cases in which they attempted to correlate data from the cystometric, cystoscopic and neurologic examinations in order to evaluate the cystometric data; they came to the conclusion that cystometry is only occasionally of positive value without other corroboratory data, either clinical or cystoscopic. Watkins,[3] using somewhat similar methods, came to a similar conclusion.

The present experiments were carried out on dogs in conjunction with other studies reported elsewhere [4] on the effects of sympathetic and parasympathetic denervation on the tonus of the rectum, colon and bladder. It seemed interesting at the same time to investigate the condition of the urinary bladder in unanesthetized dogs by means of cystometry before, and at varying intervals after, such operative procedures as bilateral sympathectomy, parasympathectomy, hypogastric ganglionectomy, resection of the pudic nerve and transverse division of the spinal cord at various levels. It seemed likely that certain difficulties in our experience with the interpretation of clinical cystometrograms might be overcome by an analysis of cystometric records obtained for animals in which definite lesions of the nerve supply to the urinary bladder had been produced experimentally.

There are a number of theoretical and practical objections inherent in the instrument as well as in the technic of its application: 1. The intermittent action of the pump causes the water to be ejected suddenly and produces a notched or toothed curve rather than a smooth one. 2. It is difficult to keep the valves clean, particularly if isotonic salt solutions are used; this is important because the clogging of the valves which invariably follows causes inaccuracies in the volume output of the pump. 3. It is somewhat troublesome to maintain proper sterilization of the apparatus. 4. The use of air in the inlet or pressure-recording system is scientifically objectionable because of the great compressibility of air.

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2. McCaughan, J. M.; Major, S. G., and Braasch, W. J.: Value of the Rose Cystometer in the Diagnosis of Neurogenic Affections of the Urinary Bladder in Man, J. Urol. **27**:229 (Feb.) 1932.

3. Watkins, K. H.: Personal communication.

4. Hershey, J. H., and McCaughan, J. M.: Surgery of the Autonomic Nervous System: I. The Effect of Parasympathetic Denervation on the Rectum and the Colon (Experimental Megacolon), J. Missouri M. A. **31**:413 (Nov.) 1934; II. The Effect of Sympathetic and Parasympathetic Denervation on the Urinary Bladder, ibid. **31**:417 (Nov.) 1934.

5. The rate at which the bladder is filled has not been adequately standardized. 6. There is no satisfactory means of controlling the temperature of the fluid in the reservoir. 7. In a sensitive or inflamed urethra or bladder, the irritation by catheter produces myogenic effects difficult to differentiate from the purely neurogenic effects. 8. In human beings value of the data based on subjective sensory experience varies greatly with the general level of intelligence and with the emotions. Nevertheless, a more important consideration is to be found in experimental data of numerous investigators with regard to the neurophysiology of the urinary bladder. For example, a review of the literature on the physiology of the urinary bladder recently published by Gruber [5] emphasizes the fact that although the bladder is innervated by both the sympathetic and the parasympathetic system each nerve supplies impulses which are both motor and inhibitory, and there seems to be little difference in the effects of the two systems except that the impulses of the parasympathetic nerves are perhaps stronger. MacDonald and McCrea [6] made similar observations with respect to gastric innervation, but of especial interest in this connection is the work of Potter,[7] who determined the intravesical pressures in unanesthetized dogs at varying intervals after parasympathetic denervation of the urinary bladder and found that they were the same as the preoperative readings.

On the other hand, there is some evidence to support a belief in permanent neurogenic imbalance as a consequence of destructive lesions of autonomic nerves. Adamson and Aird [8] reported the experimental production of megacolon by the division of the pelvic nerves in cats. This work recently has been confirmed by McCaughan and Hershey for cats, but in dogs the evidence was not so convincing. Variations among individuals and species, however, are not uncommon.[9] Furthermore, Learmonth [10] reported favorable results from division of pre-

5. Gruber, C. M.: The Autonomic Innervation of the Genito-Urinary System, Physiol. Rev. **13**:497 (Oct.) 1933.

6. MacDonald, A. D., and McCrea, E. D.: Observations on the Control of the Bladder: The Effects of Nervous Stimulation and of Drugs, Quart. J. Exper. Physiol. **20**:379, 1930.

7. Potter, J. C.: The Effects of Section of Both Sacral Nerves on Intravesical Pressure, J. Urol. **15**:197 (Feb.) 1926.

8. Adamson, W. A. D., and Aird, I.: Megacolon: Evidence in Favor of a Neurogenic Origin, Brit. J. Surg. **20**:220, 1932.

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10. Learmonth, J. R., and Braasch, W. F.: Resection of the Presacral Nerve in the Treatment of Cord Bladder: Preliminary Report, Surg., Gynec. & Obst. **51**:494 (Oct.) 1930. Learmonth, J. R.: A Contribution to the Neurophysiology of the Urinary Bladder in the Human Being, Brain **54**:147 (June) 1931. Learmonth, J. R.; Montgomery, H., and Counseller, V. S.: Resection of the Sensory Nerves of the Perineum in Certain Irritative Conditions of the External Genitalia, Arch. Surg. **26**:50 (Jan.) 1933.

sumably overacting autonomic nerves for the relief of neurogenic imbalance of the urinary bladder in human beings. However, the relative importance of destructive as compared with irritative lesions in the pathogenesis of neurogenic dysfunction of the bladder is not well known. In the experiments reported here the lesions were all destructive.

EXPERIMENTAL PROCEDURE

Female dogs of approximately similar weight and of docile disposition were chosen for training. The animals were catheterized repeatedly before operation, and cystometric readings were taken. It was found possible to train the animals

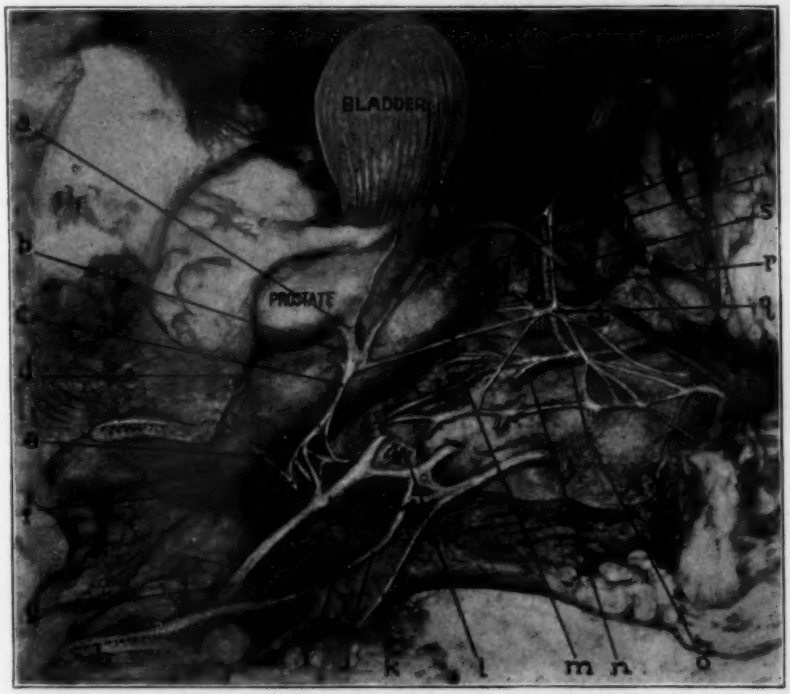

Fig. 1.—Neuro-anatomy of the rectum, colon and bladder in the dog. The pelvic plexus is indicated by *a;* the sympathetic and parasympathetic fibers to the bladder, rectum and descending colon, by *b;* the pelvic nerve, by *c;* the pubic ramus, by *d;* the pudic nerve, by *e;* the sacral plexus (first, second and third sacral roots), by *f;* the sciatic nerve, by *g;* the ileum, by *h;* the lumbar plexus, by *i;* the obturator nerve, by *j;* the femoral nerve, by *k;* the promontory of the sacrum, by *l;* the internal iliac artery, by *m;* the external iliac artery by *n;* the abdominal aorta, by *o;* the lumbar sympathetic chain, by *p;* the inferior mesenteric ganglion, by *q;* the ureter, by *r;* the inferior mesenteric artery by *s;* the hypogastric nerve, by *t,* and the lumbocolonic nerve, by *u.*

to submit easily to catheterization and to lie quietly while records of vesical capacity and pressure were obtained. The first records usually exhibited a greater tonus, as indicated by smaller capacity of the bladder and greater pressure than were shown in records made when the procedure had been repeated a number of

times. The technic used was similar to that employed in making cystometric observations on human beings, except that the subjective sensory experiences were not directly available.

A two-way catheter was introduced into the urinary bladder and a sample of urine preserved for examination. The instrument consists essentially of a water manometer by means of which fluid at room temperature may be pumped from a tank or reservoir at its base into the bladder. This pump is so adjusted that a definite quantity (10 cc.) is delivered with each revolution of a crank which is geared synchronously with a kymograph. As originally described, the inlet connector of the cystometer contained air and communicated with a mercury manometer. In these experiments, for greater accuracy, the air was replaced with water. The outlet connector of the cystometer is attached to one side of the two-way catheter and the inlet connector to the other side. The variations in intra-

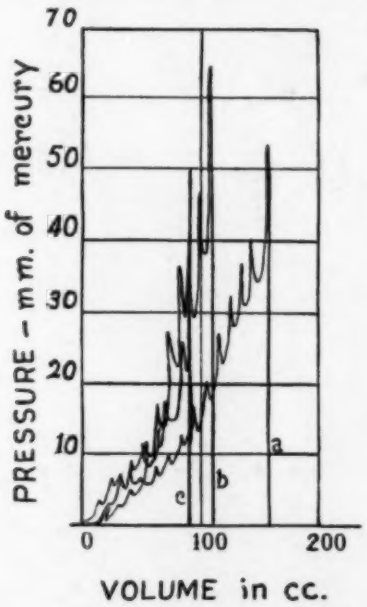

Fig. 2.—Bilateral parasympathetic denervation of the urinary bladder: *a*, preoperative cystometrogram; *b*, cystometrogram taken twelve days after operation, and *c*, cystometrogram taken thirty days after operation.

cystic pressure are thus recorded on the kymograph by means of a writing point which is attached to a float resting on the mercury column. Strict asepsis was observed during catheterization, and the urine was frequently examined for evidence of urinary infection. The fluid was introduced at a rate of approximately 20 cc. a minute. When the cystometric curves for a particular animal appeared closely similar after repeated observations, the following operative procedures were performed: (1) parasympathetic denervation of the urinary bladder (bilateral), (2) sympathetic denervation of the urinary bladder (bilateral), (3) excision of the hypogastric ganglions on both sides, (4) division of the pudic nerves on both sides and (5) division of the spinal cord at various levels. These operations were done with the animal under ether anesthesia and with strict regard for asepsis. Figure 1 shows the surgical anatomy of the dog in this region. A partial neurec-

tomy was done in every instance, and a segment of nerve from 1 to 1.5 cm. in length was excised. Following operation the animals were kept in suitable quarters and fed a uniform diet of dog biscuit and all the water they desired. At varying intervals after operation, cystometric studies were made in the manner previously described. Urinalysis was likewise made frequently. Finally each animal was killed by ether narcosis, and a thorough necropsy was performed.

TYPICAL PROTOCOLS OF THE EXPERIMENTS

EXPERIMENT 1.—*Bilateral parasympathetic denervation of the urinary bladder.*

The parasympathetic supply of a female dog weighing 11 Kg. was divided by operation on March 19. The course postoperatively was uneventful. Figure 2 shows the cystometric record before and after operation. The postmortem examination, on April 25, gave negative results.

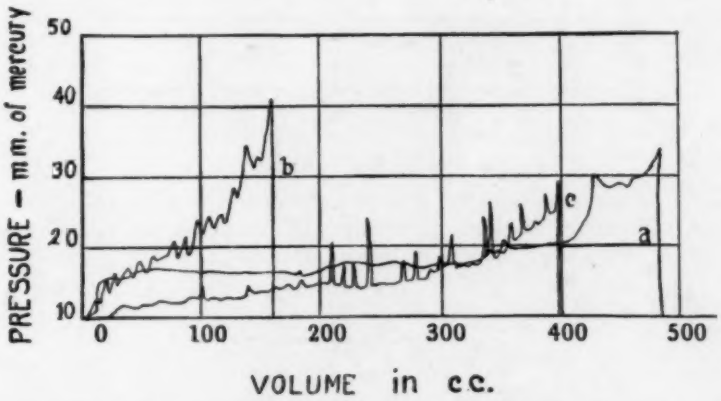

Fig. 3.—Bilateral sympathetic denervation of the urinary bladder: *a*, preoperative cystometrogram; *b*, cystometrogram taken two days after operation, and *c*, cystometrogram taken fifty days after operation.

Curves *b* and *c*, made twelve and thirty days, respectively, after parasympathetic denervation, are apparently normal curves and closely resemble the curves obtained prior to operation. There is nothing in these curves to suggest overbalance of the sympathetic nerves.

EXPERIMENT 2.—*Bilateral sympathetic denervation of the urinary bladder.*

On February 16 a sympathetic denervation of the urinary bladder was done on a female dog weighing 17 Kg. The course after operation was without especial event. Figure 3 shows the results of both preoperative and postoperative cystometric studies. The postmortem examination, on April 26, gave normal results.

This dog, a large and docile animal, frequently fell asleep during the cystometric examination. The preoperative cystometrogram, curve *a*, is unusually smooth. Curve *b*, made two days after denervation, was intentionally not completed because of the inflamed condition of the operative wound. The increase in intracystic pressure noted here may be the result of an inflammatory irritation of the abdominal wall rather than the result of parasympathetic overbalance. Curve *c*, made fifty days after operation, is similar to many of the preoperative records.

EXPERIMENT 3.—*Excision of both hypogastric ganglions.*

On February 17 the hypogastric ganglions of both sides were removed from a female dog weighing 15 Kg. The general condition of the animal after operation was good, but unfortunately the urine became infected after the second cystometric examination. Figure 4 shows the cystometric curves obtained. The postmortem examination, on March 30, revealed no abnormalities except moderate cystitis.

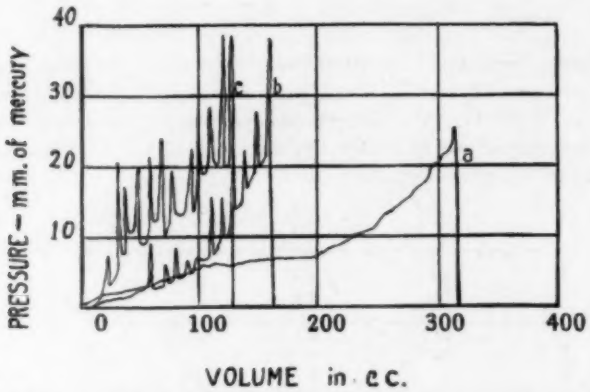

Fig. 4.—Excision of both hypogastric ganglions: *a*, preoperative cystometrogram; *b*, cystometrogram taken eleven days after operation, and *c*, cystometrogram taken thirty-seven days after operation (cystitis).

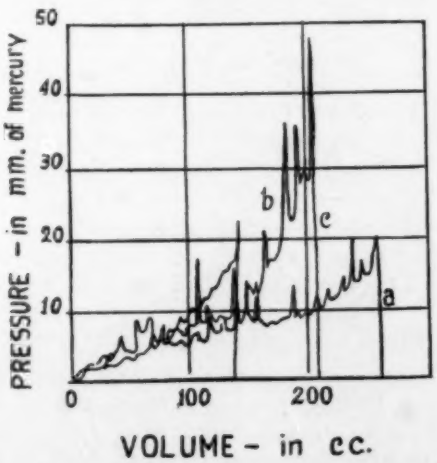

Fig. 5.—Bilateral section of the pudic nerve: *a*, preoperative cystometrogram; *b*, cystometrogram taken six days after operation, and *c*, cystometrogram taken twenty-one days after operation.

Curve *b* was made on the eleventh day after operation. The urine was free from infection at this time. Curve *c* was made thirty-two days postoperatively. At this time there was marked pyuria. The increase in intracystic pressure and the diminution in capacity are rather striking. If no cystitis was present at the time curve *b* was taken, one might conclude that complete removal of the extrinsic nerve

supply to the bladder is accompanied by definite increase in tonicity of the bladder. In curve *c* the presence of cystitis would be sufficient explanation for the lowered capacity and the increased pressure observed.

EXPERIMENT 4.—*Bilateral section of the pudic nerve.*

On April 13, the pudendal nerves of a female dog weighing 14 Kg. were divided intraperitoneally. The general condition of this animal after operation was excellent. There was neither urinary retention nor infection. The cystometric records are shown in figure 5.

Curve *b*, made six days after operation, shows a reduction in the capacity of the bladder of approximately 50 per cent, but the pressure remained about equal to

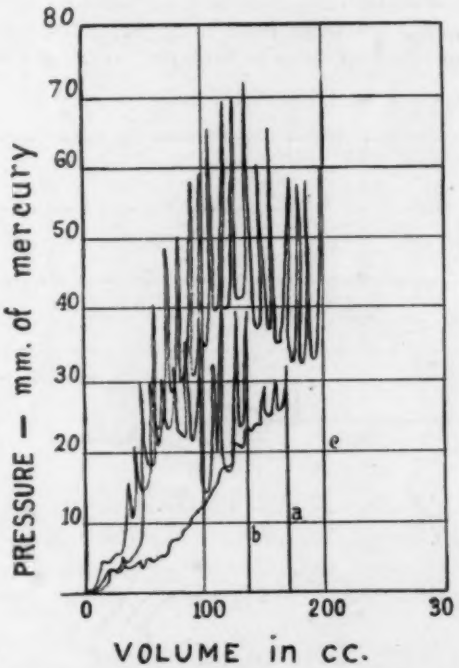

Fig. 6.—Transverse section of the spinal cord between the fourth and fifth lumbar vertebrae: *a*, preoperative cystometrogram; *b*, cystometrogram taken five days after operation, and *c*, cystometrogram taken twelve days after operation.

that noted before operation. Curve *c*, obtained three weeks after operation, shows some increase in the capacity of the bladder and a greater pressure than before. This animal was particularly restless during the cystometric examinations, and there was little uniformity even among preoperative records. Furthermore, there was no urinary infection nor retention of urine. Rose and Rollins [1e] suggested that a physiologic block of the pudic nerve caused by the prolonged pressure of the child's head brought about the condition of postpartum retention. When the pudic nerves, however, were intentionally divided by Learmonth for the relief of pruritis vulvae, no retention of urine occurred, and in one case a normal cystometrogram was obtained.

EXPERIMENT 5.—*Transverse section of the spinal cord caudad to the sympathetic outflow and cephalad to the parasympathetic supply.*

On March 23 a transverse division of the spinal cord at the level of the fourth and fifth lumbar interspaces was done on a female dog weighing 10 Kg. After operation, there were complete paralysis of the hindlegs, urinary retention (from 200 to 250 cc.) and constipation. The urine was normal on the first examination but became infected shortly after operation. Figure 6 shows the cystometric curves obtained. On the twelfth day after operation the animal was killed by ether narcosis. The postmortem examination revealed nothing abnormal except atrophy of the muscles of the hindquarters and severe hemorrhagic cystitis. The upper portion of the urinary tract showed nothing abnormal.

The preservation of the parasympathetic outflow resulted in retention of urine with incontinence, and yet when the bladder was filled a fair degree of tonus remained. Loss of sphincteric control, however, permitted a leakage of fluid from

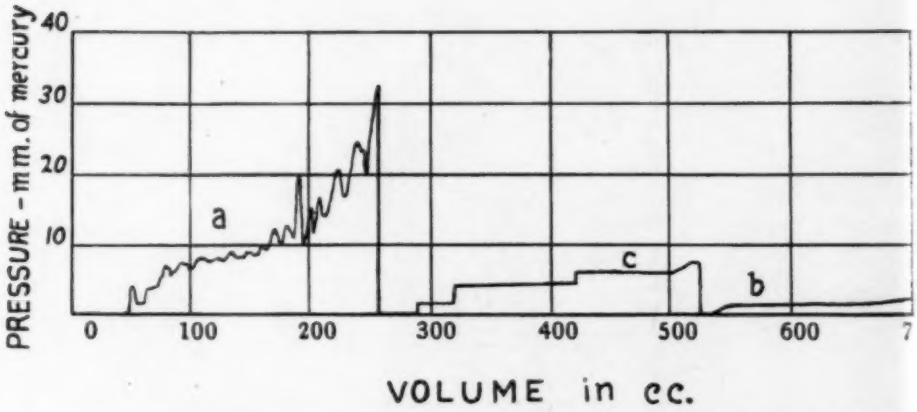

Fig. 7.—A transverse section of the spinal cord between the tenth and the eleventh thoracic vertebra: *a*, preoperative cystometrogram; *b*, cystometrogram taken two days after operation, and *c*, cystometrogram taken eleven days after operation.

the bladder fluid around the catheter. The cystometric curve fell gradually after this occurred. Curve *b* was made five days and curve *c* two days after section of the cord. In curve *c*, despite the cystitis, there is evident increase in both intracystic pressure and capacity. The cause of the extreme notching or toothlike effect of these curves is not entirely clear. It occurs with each ejection of fluid from the pump, but here it was exaggerated far more than in any of the previous experiments.

EXPERIMENT 6.—*Transverse section of the spinal cord cephalad to both the sympathetic and the parasympathetic outflow.*

On March 23, the spinal cord of a female dog weighing 13 Kg. was sectioned transversely between the ninth and the tenth thoracic vertebra. After operation there were paralysis, constipation and urinary incontinence, with marked retention of urine (400 to 500 cc.). The urine on the second examination showed a slight degree of infection. Figure 7 shows the cystometric curves before and after oper-

ation. This animal died on the fifteenth day after operation. At postmortem examination the bladder was markedly contracted, and the mucosa was slightly hemorrhagic. The kidneys, ureter, colon and rectum grossly appeared normal.

In this experiment both the sympathetic and the parasympathetic supply were destroyed. There was a much greater degree of urinary retention and incontinence than in the previous experiment. In curve *b*, made two days after operation, and in curve *c*, made eleven days postoperatively, it will be noted that the capacity of the bladder is tremendously increased, whereas the intracystic pressure is very low. Leakage about the catheter also occurred when the bladder became overdistended. This curve is similar to the cystometrograms obtained clinically in cases of tabes dorsalis and of other destructivue lesions of the spinal cord in human beings.

EXPERIMENT 7.—*Control cystometrograms from a normal dog.*

Beginning March 3, a series of cystometrograms were made on a female dog weighing 11 Kg. Figure 8 shows three such curves: (*a*) the first curve made;

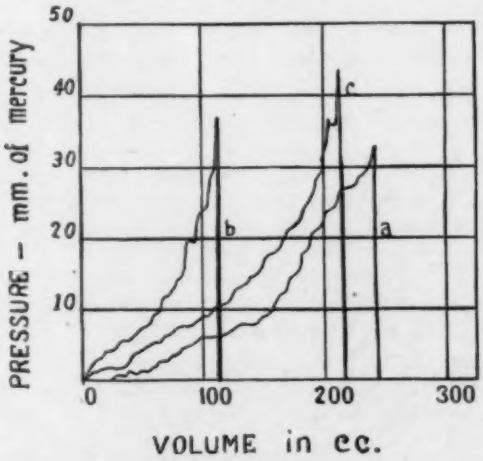

Fig. 8.—Control cystometrograms from a normal dog: *a*, first cystometrogram in the series; *b*, intermediate cystometrogram in the series, and *c*, last cystometrogram in the series.

(*b*) the intermediate curve, and (*c*) the final curve. All the other curves fell within this range. The animal cooperated satisfactorily, and the experiments represent very well the degree of variation which may be expected under normal conditions.

COMMENT

Destructive lesions of the extrinsic nerve supply to the urinary bladder in dogs produced by excising segments 1 to 1.5 cm. in length from the sympathetic, parasympathetic or pudic nerves did not cause appreciable disturbance in the physiology of the bladder. The normal character of cystometric curves was not significantly altered early or late by these procedures. Transverse division of the spinal cord above the lumbar outflow produced the typical picture of "cord bladder" clinically. This condition was readily demonstrated by means of the

cystometer. This evidence tends to support the views previously expressed by McCaughan, Major and Braasch [2] with regard to the value of cystometry clinically and is generally in accord with the results obtained from experimentation with animals by a majority of investigators.[5]

The importance of irritative lesions in producing vesical dysfunction deserves more careful investigation. A practical method for accomplishing prolonged stimulation of nerve tissue in experimental animals has been suggested recently by Loucks [11] and also by Cannon.[12] We have been using a modification of the Cannon technic and propose to demonstrate the effects, if any, of this form of stimulation on the urinary tract, rectum and colon.

CONCLUSIONS

The cystometer is of greatest value in demonstrating the effects on the urinary bladder of destructive lesions of the spinal cord. When the lesion was placed elsewhere, as in the extrinsic nerve supply, the cystometric curves were generally normal or of no particular diagnostic aid.

Dr. F. W. Braasch of the Section on Urology at the Mayo Clinic, Rochester, Minn., provided the cystometer used in these experiments.

11. Loucks, R. B.: Preliminary Report of a Technique for Stimulation or Destruction of Tissues; Beneath the Integument and the Establishing of Conditioned Reactions with Faradization of the Cerebral Cortex, J. Comp. Psychol. **16**:439 (Dec.) 1933.

12. Cannon, Bradford: A Method of Stimulating Autonomic Nerves in the Unanesthetized Cat with Observations on the Motor and Sensory Effects, Am. J. Physiol. **105**:366, 1933.

VASO-ORCHIDOSTOMY WITH INTERPOSED SPERMATOCELE

A PROCEDURE FOR TREATMENT OF STERILITY

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The first recorded surgical attempt to reestablish the seminiferous channels was that of Bardenheuer,[1] who in 1886, following excision of the epididymis for tuberculosis, implanted the cut distal end of the vas deferens in the testis. Since then many operations have been devised for the relief of male sterility due to obstructive lesions in the epididymides. These fall into three main categories:

1. Vaso-epididymostomy [2]
2. Vaso-orchidostomy [3]
3. Miscellaneous operations
   - (*a*) Vaso-orchidocystostomy [4]
   - (*b*) Sac epididymostomy [5]

From the Surgical Services of the Beth Israel and the Montefiore Hospitals.

1. Bardenheuer, B.: Die operative Behandlung der Hodentuberculose durch Resection des Nebenhodens, Mitt. a. d. Köln. Bürgerhospital **3**:129, 1886.

2. (*a*) Bogoljuboff, W.: Experimentelle Untersuchungen über die Anastomosenbildung an den ableitenden Samenwegen, Arch. f. klin. Chir. **72**:449, 1904. (*b*) Hagner, F.: Anastomosis of Vas Deferens to Epididymis, Tr. Am. A. Genito-Urin. Surgeons **8**:142, 1913; (*c*) Sterility in the Male, J. Urol. **13**:377, 1925; (*d*) Sterility in the Male, Surg., Gynec. & Obst. **52**:330, 1931. (*e*) Lespinasse, V. D.: Obstructive Sterility in the Male, J. A. M. A. **70**:448 (Feb. 16) 1918. (*f*) Martin, E.; Carnett; Levi, and Pennington : Pennsylvania M. Bull. **20**:388, 1902; (*g*) Sterility from Obstruction at the Epididymis Cured by Operative Means, New York M. J. **78**:697, 1903.

3. (*a*) Rasumowsky, W. J.: Eine neue Operation am Hoden, Arch. f. klin. Chir. **65**:2, 1902. (*b*) Rolnick, H. C.: An Operation for Sterility in the Male, Surg., Gynec. & Obst. **45**:557, 1927. (*c*) Stutzin, J. J.: Vaso-orchidostomie, Ztschr. f. Urol. **18**:132, 1924; (*d*) Zur Frage der Vaso-orchidostomie, Zentralbl. f. Chir. **53**:264, 1926. Bardenheuer.[1]

4. (*a*) Gara, M.: Ueber Cysten und Hohlraumbildungen, Zentralbl. f. Chir. **52**:2238, 1925. (*b*) Lichtenstern, R., and Gara, M.: Vaso-orchidostomie, Ztschr. f. urol. Chir. **24**:156, 1928.

5. Lespinasse, V. D.: (*a*) The Relief of Sterility by Means of Permanent Epididymostomy, J. A. M. A. **63**:1916 (Nov. 28) 1914; (*b*) Tr. A. Genito-Urin. Surgeons **12**:339, 1919; (*c*) Sterility in the Male, Illinois M. J. **61**:509, 1932.

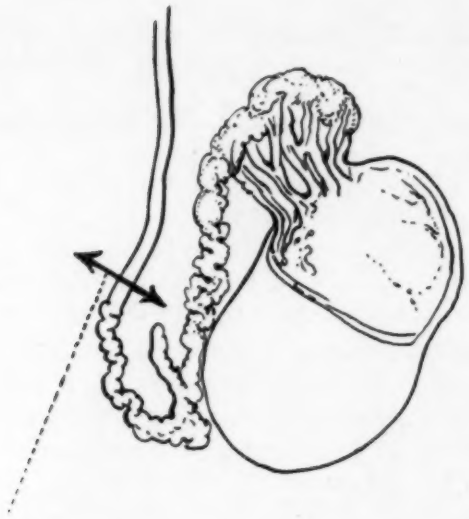

Fig. 1.—The first stage in the operation, permanent vasostomy, in which the vas deferens is cut.

Fig. 2.—A step in the first stage showing a blunt needle inserted into the vas deferens for the injection of iodized oil for seminal vesiculography.

(*c*) Transplantation of the saphenous vein as a substitute for the vas deferens [6]

(*d*) Vaso-urethrostomy [7]

There are valid objections to most of these operations on anatomic and physiologic grounds.[8]

It appears from a review of the literature that Martin's vaso-epididymostomy with technical modifications is the most popular and the most successful operation for the reestablishment of the seminiferous channels following bilateral obstructive epididymitis. The

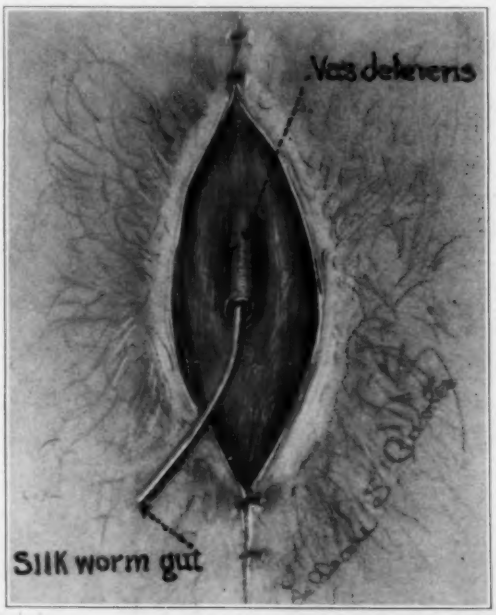

Fig. 3.—The first stage completed. Note that the skin is loosely sutured about the vasostomy opening, leaving a raw surface for epithelization. Scrotal hair, though shaved at the time of the operation, has been diagrammatically inserted.

largest series of cases has been reported by Hagner.[2d] He achieved successful results in nineteen of thirty-one patients, or 61 per cent. However, this operation has been successful in the hands of only a few surgeons and has never attained widespread popularity. The large number of unreported failures is undoubtedly the reason for the pessi-

6. von Mezõ, A.: Neue Richtungen in der Behandlung des mechanischen Aspermatismus, Ztschr. f. urol. Chir. **21**:33, 1926.

7. Boari, A.: L'Implanation des canaux déférents dans l'urèthre antérieur, Semaine méd. **29**:445, 1909.

8. Lichtenstern and Gara.[4b] Rolnick.[3b]

mistic outlook toward this relatively nondangerous operation for an otherwise hopeless condition.

On the other hand, it is agreed that the likelihood of success is greatly enhanced if a spermatocele is present or can be formed artificially.[9] Lespinasse,[5a] Rolnick [10] and Lichtenstern and Gara [4b] have worked toward this end, with, however, limited or no success. It would seem that the solution of this problem, i. e., the artificial creation

Fig. 4.—A vasoseminal vesiculogram demonstrating the patency of both vasa deferentia. The seminal vesicles are normal. Note the iodized oil in the bladder.

of a spermatocele, would materially increase the percentage of success of operations to reestablish the seminiferous channels. With this in mind I have attempted to devise an operative procedure which would more nearly reproduce the normal anatomic conditions.

The criteria for this operation were as follows: 1. The entire spermatogenic tissue should be used. 2. The testis should not be

9. Hagner.[2d] Rolnick.[3b]

10. Rolnick, H. C.: The Etiology of Spermatocele, J. Urol. **19**:613, 1928.

damaged. 3. The site of the anastomosis should be completely epithelial so that a minimum of scar was formed. 4. A funnel-shaped sac lined with epithelium, analogous to a spermatocele, should be established to unite the larger cut open surface of the tubules of the epididymis or of the rete testis to the smaller divided end of the vas deferens.

Following experiments on animals in the pathologic laboratories of the Montefiore Hospital, this operation for the reestablishment of the seminiferous channels was carried out in two stages. The first stage

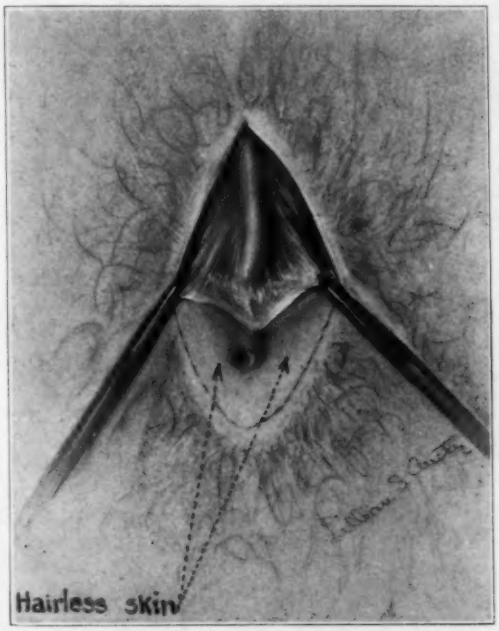

Fig. 5.—The second stage in the operation, vasosac orchidostomy. The vas deferens is freed with an attached cuff of new hairless skin.

consisted of permanent vasostomy. After complete healing had taken place the second stage, vasosac orchidostomy, was performed.

TECHNIC OF THE OPERATION

First Stage: Permanent Vasostomy.—The vas deferens is isolated through a small high scrotal cutaneous incision. Vasoseminal vesiculography is then performed by the injection of iodized oil into the distal portion of the vas deferens to demonstrate its patency into the urethra (figs. 1, 2 and 4).

The vas is cut across close to the epididymis, and its distal end implanted into the scrotal skin, creating a permanent vasostomy. A strand of silkworm gut is left in the lumen of the vas deferens. It is very important that the scrotal skin be loosely sutured around the implanted end of the vas deferens, leaving a raw

area. This allows a cuff of new hairless epithelium to grow inward from the edges of the scrotal wound to and surrounding the vasostomy opening (fig. 3).

Second Stage: Vasosac Orchidostomy.—The testis and epididymis are exposed through a low scrotal incision. The epididymis is aspirated or incised for spermatozoa; the testis can be aspirated if necessary. The epididymis is incised freely or cut across at the place where spermatozoa are found. If no spermatozoa are found in the epididymis, an epididymectomy is performed, cutting transversely across the efferent ducts of the rete testis, leaving them gaping widely open (fig. 6 *A*). Bleeding is carefully controlled, preferably by pressure and the application of epinephrine. The vas deferens is freed with a cuff of hairless skin remaining attached around the vasostomy opening (fig. 5). The edges of the cutaneous cuff are sutured to the cut margins of the epididymis or to the tunica albuginea around but at some distance from the sectioned efferent ducts of the rete testis, forming an umbrella-like sac (fig. 6). The incision of scrotal skin is closed with interrupted plain catgut sutures without drainage.

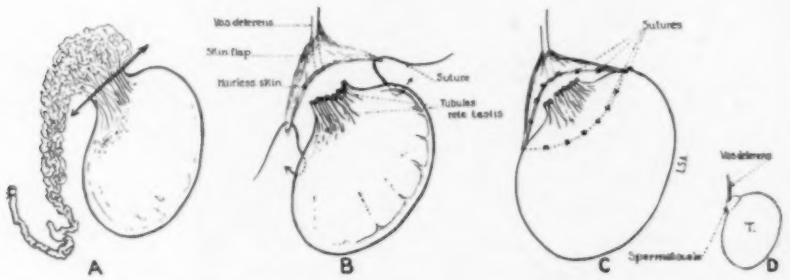

Fig. 6.—A diagram of the steps in the vasosac orchidostomy. *A* indicates the stage at which the epididymis is cut, *B* and *C*, the skin flap with the end sutures, and *D*, the external view of the completed operation.

COMMENT

By performing the operation in two stages, i. e., with preliminary vasostomy, one can be fairly certain that the opening of the vas deferens is patent before proceeding with the major step of the anastomosis. This tends to eliminate late stricture and occlusion of the vas deferens at the site of anastomosis, a frequent cause of failure of these operations.[3b] If for some reason the vasostomy opening should close, another can easily be made.

In addition, the presence of an umbrella-like cuff of hairless new skin epithelium about the vas deferens (figs. 5 and 6) enables one to place the sutures a good distance away from the site of anastomosis. Thus there is no irritation or inflammation by foreign bodies near the opening of the epididymal tubules or the efferent ducts of the rete testis. This makes the operation quite simple for surgeons of ordinary skill and eliminates another cause of failure of vaso-epididymostomy,

i. e., inflammation and necrosis about the suture line with later scar contracture closing the anastomosis opening.[11]

Though Lespinasse in 1916 [5a] proposed the formation of a spermatic sac or spermatocele of vein, skin or bladder mucosa, there is no report of such a procedure ever having been carried out. Unfortunately Lespinasse did not consider the possibility of implanting the vas deferens into such an artificially created spermatic sac but confined its application to cases in which the pelvic vas deferens was occluded. He suggested periodic tapping of the sac for purposes of artificial insemination. Another obstacle to the ultimate success of his procedure was the use of Delbet's rubber instead of living epithelial tissue to form the sac. So far as can be ascertained from the literature, skin has never before been used to create an artificial spermatocele or spermatic sac into which the vas deferens has been implanted. In addition, no mention has been found of the application of vasoseminal vesiculography for the purpose of proving patency of the seminiferous system from the site of anastomosis of the vas deferens into the urethra.

The experimental work and clinical experiences on which this technic is founded will be reported in a later communication.

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11. Rolnick.[3b] Stutzin.[3d]

MELANOSIS COLI

ITS CLINICAL SIGNIFICANCE

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AND

DAVID A. SUSNOW, M.D.

SAN FRANCISCO

Since its first description by Cruveilhier [1] in 1829 melanotic pigmentation of the large intestine had been only occasionally observed. From his autopsy observations made in 1858, Virchow [2] applied the term melanosis coli to the condition. It was 1911 before the first clinical report by Pick [3] appeared on the recognition sigmoidoscopically of this discoloration of the intestine.

While melanosis coli is not a rare condition it is practically unknown to the average physician. When observed sigmoidoscopically it usually has been passed by or referred to casually as "brown bowel" or by some other descriptive term and its clinical significance overlooked. The latter circumstance has prompted us to present this paper.

GROSS APPEARANCE THROUGH THE SIGMOIDOSCOPE

The mucosal pigmentation in melanosis coli varies widely in different persons. It is usually some shade of brown ranging from a light, almost gray, tone to a deep, dark hue almost inky black. In the earliest stages the pigmentation is demonstrable only microscopically. Most writers have described the pigmentation as being deepest in the cecum and ascending colon and becoming gradually less pronounced distally and rarely being more intense in the distal part of the intestine. The entire colon usually is not involved.

According to Lubarsch and Borchardt,[4] the pigmentation is mainly in the cecum, appendix and ascending colon. Lignac [5] stated that the

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1. Cruveilhier, J.: Anatomie pathologique du corps humain, Paris, J.-B. Baillière, 1829-1835, vol. 19, p. 6.

2 Virchow, Rudolf: Die pathologischen Pigmente, Virchows Arch. f. path. Anat. **1**:379, 1847.

3. Pick, L.: Ueber die Melanose der Dickdarmschleimhaut, Berl. klin. Wchnschr. **48**:840 (May 8); 884 (May 15) 1911.

4. Lubarsch, O., and Borchardt, H.: Die Melanosis Coli, in Henke, F., and Lubarsch, O.: Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, 1929, vol. 4, p. 75.

5. Lignac, G. O. E.: Ueber sogenannte "Melanosis Coli," Krankheitsforschung **2**:162, 1926.

melanosis is mainly in the cecum and rectum, with occasional pigmentation in the ileum. Stewart and Hickman [6] reported that the discoloration is almost invariably more intense in the cecum and ascending colon, although rarely the melanosis may be deeper in the distal than in the proximal portion of the large intestine. Bockus [7] and his co-workers found that when the pigmentation is not uniformly distributed it is always more intense in the rectum and in many cases gradually diminishes in the upper portion of the descending intestine.

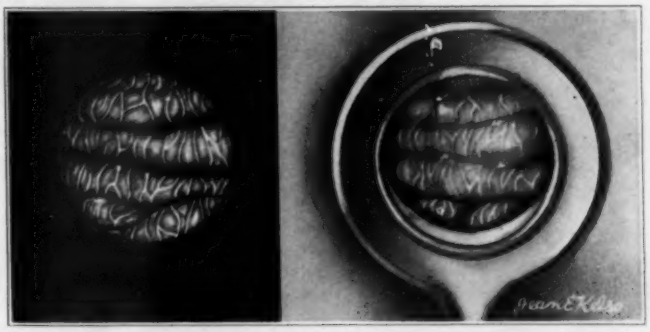

Fig. 1.—A sketch showing the common form of melanosis coli.

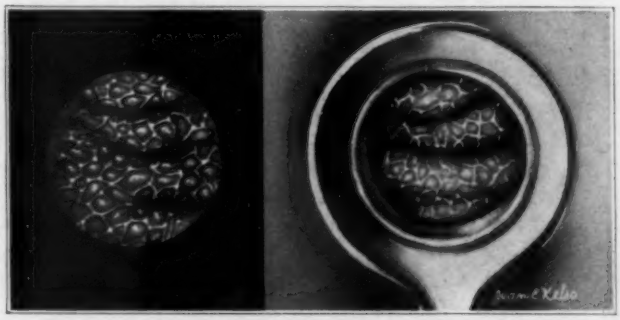

Fig. 2.—A sketch showing the crocodile hide type of melanosis coli.

Other than a melanotic discoloration there are usually no changes in the mucosa of the intestine. Frequently there is accompanying mucous colitis. There are no indications of pigmentation elsewhere, although metastasis of the pigment to the mesocolic lymph nodes occurs at times. There is no evidence as yet as to the more widespread

6. Stewart, M. J., and Hickman, E. M.: Observations on Melanosis Coli, J. Path. & Bact. **34**:61, 1931.

7. Bockus, H. L.; Willard, J. H., and Bank, Joseph: Melanosis Coli: The Etiologic Significance of the Anthracene Laxatives, J. A. M. A. **101**:1 (July 1) 1933.

metastasis of melanosis. The pigmented area of the portion of the intestine affected is broken up into small polyhedral shapse by a network of fine unpigmented lines which correspond, according to Pick, to the ramifications of the mucosal blood vessels. In less advanced stages the pigmented areas are smaller as well as lighter, with a brownish stippling against a normal-appearing mucosal background. The solitary follicles of the intestine, being devoid of pigment, stand out as small yellow follicles the size of a pinhead. They are marked even in the early stages of melanosis and are helpful in making macroscopic diagnosis.

The appearance of the mucosa of the intestine has been compared to that of snake skin, crocodile hide, tiger skin and a cross-section of nutmeg.

HISTOLOGIC APPEARANCE

The pigmentation is usually confined to the stroma of the mucous membrane, where it lies in the cytoplasm of large mononuclear cells, the exact nature of which has not been settled. The distribution in the mucosa varies. In mild cases it is usually in the mucosal villi, while in the advanced stage it is either in the depths of the mucosa close to the muscularis mucosae or scattered throughout its thickness. This distribution is probably due to the formation of melanin superficially followed by a migration downward.

The pigment is usually intracellular, but free granules are also present. The epithelium of the mucosa is usually pigment-free.

CHARACTER AND SOURCE OF THE PIGMENTATION

There is a great diversity of opinion with regard to the character and source of the pigmentation in melanosis coli. It is generally believed that the pigment is a true melanin or melanin-like substance. It was formerly believed that pigmentation of the intestine was due to ingestion of preparations of heavy metals, such as mercury or lead. This view, however, was not substantiated by subsequent chemical analysis of sections of pigmented melanotic intestines. From his chemical studies, Virchow suggested a hematogenous origin. This view was put forth by others, and the condition is still referred to in many places in the literature as hemochromatosis (Lynch [8]; Gant [9]). It is difficult to explain the limitation of the pigmentation to the colon if the source is hematogenous.

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8. Lynch, J. M.: Diseases of the Rectum and Colon, Philadelphia, Lea & Febiger, 1914, p. 374.

9. Gant, S. G.: Diseases of the Rectum, Anus and Colon, Philadelphia, W. B. Saunders Company, 1923, p. 86.

Vascular congestion with a predisposition to the formation of pigment (Solger[10]), hemorrhage into the intestine with subsequent bacterial action (Lignac[5]) and disturbance of the chromogenic function of the liver (Lynch[8]) have been advanced as probable causes of melanosis coli.

According to Pick, the aromatic products of protein disintegration of the contents of the intestine (indole, skatole) are absorbed from the

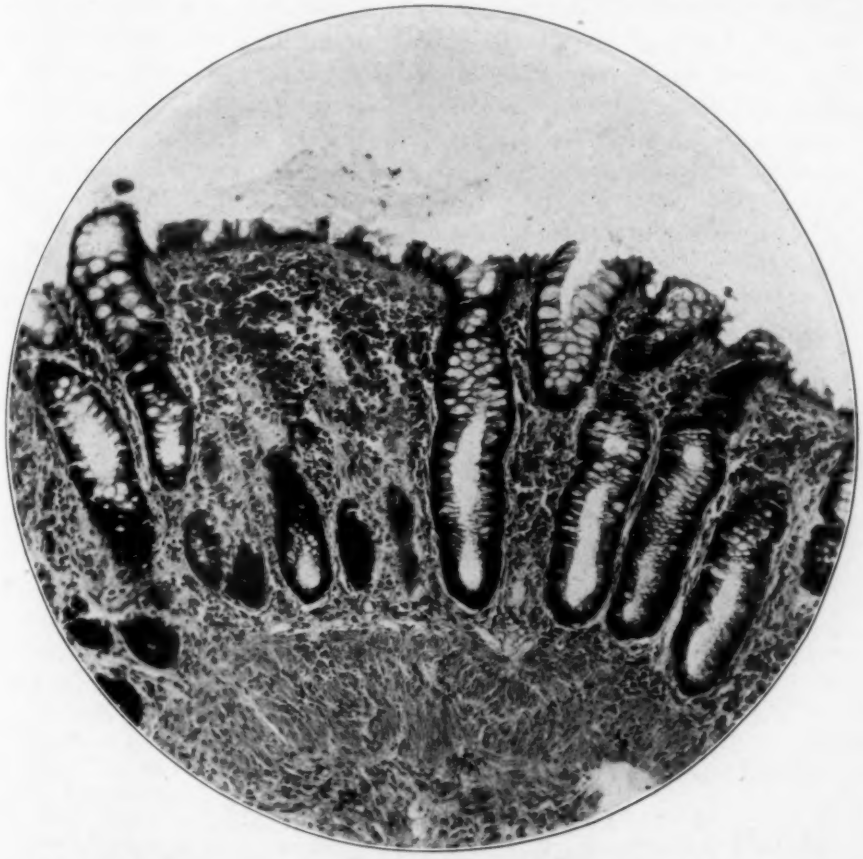

Fig. 3.—A high power photomicrograph showing pigmentation in the stroma of the mucous membrane of the rectum.

intestine and converted into melanin within the connective tissue cells of the mucosa by the action of a tyrosinase-like ferment produced by the connective tissue cells. This ferment is produced only in certain persons. Other theories propose the formation of a ferment in the

10. Solger, F. B.: Dickdarmmelanose, Inaug. Dissert., Greifswald, 1898; quoted by Lubarsch and Borchardt.[4]

contents of the intestine and the production of melanin by that portion of the mucosa which comes in contact with the ferment (McFarland [11]), the production of pigment by bacterial action (Dalldorf [12]) and the derivation of melanin from foodstuffs and then phagocytosis by the cells of the mucosa of the intestine (Laidlaw [13]).

The etiologic significance of the anthracene laxatives in relation to melanosis coli has recently been described by Bockus and his co-workers.[7] These observers concluded that "the anthracene laxatives either contain or elaborate a pigment within the bowel which is phagocytised by the deep mucosal cells causing melanosis coli." They obtained a history of the long use of anthracene laxatives, usually cascara sagrada, in 100 per cent of their cases of melanosis of the bowel. The association of melanosis with constipation or stasis seems

Clinical Features in Patients with Melanosis of the Bowel

Patient	Sex	Age, Years	Chief Complaint	Appearance of Mucosa	Laxative Taken	Other Observations
1	M	56	Mucous discharge from rectum	Scattered pigmented points	Cascara sagrada	Mucous colitis
2	F	50	Bleeding by rectum	Alligator skin	Cascara sagrada	Mucous colitis
3	M	69	Pain in rectum	Alligator skin	Aloe, strychnine and phenolphthalein*	Proctitis; internal hemorrhoids
4	F	52	Bleeding by rectum	Tiger skin	Cascara sagrada	Internal hemorrhoids
5	F	40	Constipation	Alligator skin	Cascara sagrada	Internal hemorrhoids; mucous colitis
6	M	64	Bleeding by rectum	Alligator skin	Cascara sagrada	Internal hemorrhoids
7	F	41	Pain in rectum	Alligator skin	Cascara sagrada	Fissure in the anus

* Aloe contains an anthracene derivative.

to be definitely established. This probably explains the frequency of melanosis in surgically resected appendexes and in malignant processes of the intestine.

REPORT OF CASES

In 7 of 200 persons examined by sigmoidoscope in our clinic we observed melanotic discoloration of the bowel. This was an incidence of 3.5 per cent. In five the appearance could be likened to an alligator skin. Another suggested somewhat the cross-section of nutmeg and the other presented widely separated stipplings of light brown pigmentation. The table summarizes certain clinical features of our cases.

11. McFarland, W. L.: Pigmentation of the Hind-Gut, J. A. M. A. **69**:1946 (Dec. 8) 1917.

12. Dalldorf, G. J. G.: Melanosis Coli, Beitr. z. path. Anat. u. z. allg. Path. **78**:225 (Aug.) 1927.

13. Laidlaw, G. F.: Melanoma Studies, Am. J. Path. **8**:447 (Sept.) 1932.

The most striking feature was that all these seven patients took cascara sagrada. This is quite in agreement with the report of Bockus and his co-workers. It is of interest that when one of our patients was told that she had "brown bowel" she suggested that it might be due to the cascara sagrada which she had been taking for a long time, "for cascara is brown."

In all our cases constipation had been present for many years. Examination disclosed intestinal stasis in each. The headache, drowsiness, dizziness and other symptoms of which these patients complained were probably due to the colonic stasis and not to the melanosis, for similar symptoms may occur in patients with stasis of the colon without melanosis. It is our belief that melanosis coli per se produces no symptoms. We have no evidence that this pigmentation of the bowel is detrimental.

Contrary to the report of most observers that the pigmentation is deepest in the cecum and ascending colon and becomes more intense in the distal part of the intestine, we found that the pigmentation was deepest distally, in the rectum just inside the anal sphincter. Above this area of deepest pigmentation the coloration became gradually lighter as far as we could determine sigmoidoscopically.

Bockus reported that from four to twelve months is usually necessary for a complete disappearance of the pigmentation when proper treatment is instituted. We have observed that following treatment for the constipation and usually associated catarrhal colitis there was a partial clearing up of the pigmentation. Our treatment consisted of nonanthracene cathartics, enemas of tap water, and a nonputrefactive diet. We have not observed a complete disappearance. Our first patient has been under observation and treatment for one and one-half years.

SUMMARY

The gross and histologic characteristics of melanosis coli have been reviewed.

Melanosis coli was observed in seven of two hundred consecutive persons who underwent sigmoidoscopic examinations.

The chief apparent factors were chronic constipation and the use of anthracene laxatives over a long period of time.

The pigmentation partially disappears when the anthracene laxatives are stopped and steps are taken for the correction of the constipation.

Melanosis coli per se is not detrimental.

GANGRENE OF THE BUTTOCK, PERINEUM AND SCROTUM DUE TO ENDAMOEBA HISTOLYTICA

REPORT OF A CASE

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AND
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NASHVILLE, TENN.

In a recent paper one of us (F. L. M.)[1] presented a clinical and bacteriologic differential diagnosis between certain varieties of acute and chronic infectious gangrene of the skin. One of the chronic forms which was described in that summary was attributed to the pathogenic action of Endamoeba histolytica, but it was pointed out that in the reports of cases which had appeared in the literature no mention had been made of a careful study of the anaerobic organisms present in the lesion and that in many cases the identification of the protozoon present as E. histolytica was open to question. In certain of the cases, to be sure, there was direct evidence and in others circumstantial evidence that E. histolytica was present and was playing a prominent, if not a predominant, rôle in the production and continuation of the disease process.

Recently we have had the opportunity of observing and treating a patient in whose lesion we were able not only to identify E. histolytica, apparently actively engaged in a destructive process in the periphery of the affected area, but to rule out by careful anaerobic studies the presence and activity of any anaerobic or micro-aerophilic organisms such as are found constantly in certain other forms of chronic gangrene with which this disease might be confused. We have also been able to observe certain clinical characteristics of this disease which might be helpful in differentiating it clinically from some of the other types of infectious gangrene of the skin. For these reasons it seems worth while to report our observations.

From the Surgical Service of the Presbyterian Hospital, New York, and the Department of Preventive Medicine and Public Health, Vanderbilt University School of Medicine, Nashville, Tenn.

1. Meleney, F. L.: A Differential Diagnosis Between Certain Types of Infectious Gangrene of the Skin, Surg., Gynec. & Obst. **56**:847, 1933.

LITERATURE

Amebiasis is generally believed to be a tropical disease, yet it frequently occurs sporadically throughout the temperate zones, and the recent experience in Chicago indicates that it may reach epidemic proportions in northern climates.[2] Amebic infection of the skin has usually been described as occurring after the spontaneous or surgical drainage of a deep focus of amebic infection, such as an abscess in the liver or a peritoneal abscess following a perforated ulcer of the colon. Such cases have been reported by Heimburger,[3] Nasse,[4] Daborn and Heymann,[5] Heymann and Ricou,[6] Gauducheau,[7] Carmini,[8] Ch'eng,[9] M. F. Engman Jr. and H. E. Meleney,[10] Cole and Heideman,[11] Marwits and Van Steenis [12] and others. Maxwell [13] and Van Hoof [14] described fistulas, abscesses and ulcers in the region of the anus and buttocks which they attributed to the ameba. M. F. Engman Sr. and Heithaus [15] and Hansen and Stark [16] described lesions of the skin which were not associated with

2. Bundesen, H. N.; Tonney, F. O., and Rawlings, I. D.: The Outbreak of Amebiasis in Chicago During 1933: Sequence of Events, J. A. M. A. **102**:367 (Feb. 3) 1934; Amebiasis Outbreak in Chicago: Report of a Special Committee, ibid. **102**:369 (Feb. 3) 1934.

3. Heimburger, L. F.: Amebiasis Cutis, with a Survey of the Medical Literature to Date, Arch. Dermat. & Syph. **11**:49 (Jan.) 1925.

4. Nasse, D.: Ueber einen Amoebenbefund bei Leberabscessen, Dysenterie und nosocomial Gangrän, Arch. f. klin. Chir. **43**:40, 1892.

5. Daborn and Heymann: Abcès amibien du foie, suivi de phagédénisme de la plaie opératoire et d'abcès cutané amibien, Bull. Soc. méd.-chir. de l'Indo-Chine **3**:518, 1912.

6. Heymann and Ricou: Un cas de phagédénisme cutané amibien, Bull. Soc. méd.-chir. de l'Indo-Chine **7**:64, 1916.

7. Gauducheau: A propos de l'ulcère phagédénique amibien, Bull. Soc. méd.-chir. de l'Indo-Chine **7**:118, 1916.

8. Carmini, A.: Phagédénisme cutané amibien, Bull. Soc. path. exot. **5**:216 and 799, 1912.

9. Ch'eng, C. C.: Cutaneous Amoebiasis Resulting from Ruptured Liver Abscess Coincident with Kala Azar: Report of Case, China M. J. **45**:350, 1931.

10. Engman, M. F., Jr., and Meleney, H. E.: Amebiasis Cutis (Endameba Histolytica): Report of Two Cases, Arch. Dermat. & Syph. **24**:1 (July) 1931.

11. Cole, W. H., and Heideman, M. L.: Amebic Ulcer of Abdominal Wall Following Appendectomy with Drainage: Report of a Case, J. A. M. A. **92**:537 (Feb. 16) 1929.

12. Marwits, E. L., and Van Steenis, P. B.: A Case of Amebiasis Cutis After Incision of Pericecal Abscess, Urol. & Cutan. Rev. **35**:313, 1931.

13. Maxwell, J. L.: Fistulous Diseases of the Buttocks, Tr. Roy. Soc. Trop. Med. & Hyg. **6**:50, 1912.

14. Van Hoof, L.: Abcès, fistules et ulcères, d'origine amibienne, Ann. Soc. belge de méd. trop. **6**:45, 1926.

15. Engman, M. F., and Heithaus, A. S.: Amebiasis Cutis, J. Cutan. Dis. **37**:715, 1919.

16. Hansen, G. M., and Stark, L.: Amebiasis Cutis with Report of Case, Nebraska M. J. **16**:23, 1931.

an internal amebic disease and which were thought to be infected with amebas introduced from without.

Ngai and Frazier [17] recently reported three cases of a condition which apparently falls into the group of cutaneous amebiasis. Their first patient suffered from a perianal condylomatous lesion with a punched-out ulceration which gradually increased in size for three weeks. This was preceded by a period of bloody diarrhea lasting for three weeks. On his admission to the hospital an examination for amebas in the stools gave negative results, and no spirochetes could be found in the lesion. Cultures yielded a nonhemolytic streptococcus and an unidentified gram-positive bacillus. Anaerobic cultures were not reported. The lesion failed to respond to local nonspecific treatment. Two weeks after the patient's admission a scraping from the wall of the ulcer was examined and E. histolytica was found. Its presence in the tissue was confirmed by biopsy. The lesion promptly healed after the administration of emetine hydrochloride hypodermically and chiniofon locally. There seems to be no doubt that the amebas were active in the pathologic process and were probably responsible for it. The second patient had a syphilitic lesion of the urethra secondarily contaminated by amebas. The third patient had a papilloma of the anus secondarily invaded by amebas. The authors were not sure that the amebas were of primary importance in the last two cases. Their report contained a good review of the literature.

REPORT OF CASE

History.—S. J. W., a Chinese kitchen helper, aged 51, was admitted to the Emergency Clinic of the Presbyterian Hospital on Dec. 22, 1933. He spoke no English, and his "interpreter" was not able to give a detailed history or to answer questions except to say that the patient was known to have had diabetes for several years. The man was obviously desperately ill.

On the second day we were able to obtain the following fragmentary notes: Eight years before admission he was found to have diabetes. Under treatment by a physician he was rendered sugar-free. He had taken insulin from time to time, but none recently. During the previous two years he had lost from 40 to 50 pounds (18.1 to 22.7 Kg.) and had had periods of bloody diarrhea which came on every two or three months and lasted for about two weeks. There was no associated abdominal or rectal pain with these attacks of bleeding, and he had received no medication for them. One month before admission he noticed a small, hard, tender lump just to the right of the anus. This gradually increased in size and tenderness for three weeks until he could not sit down or defecate without pain. About ten days before admission the whole area "burst" and discharged large quantities of foul-smelling pus and necrotic tissue. Since that time he had steadily gone down hill.

17. Ngai, S. K., and Frazier, C. N.: Cutaneous Amoebiasis: A Review and a Report of Three Cases Observed in North China, Chinese M. J. **47**:1154, 1933.

Examination.—The patient was dehydrated and had an acetone breath, and the lesion filled the surrounding atmosphere with a foul, cadaveric odor. His skin was extremely pale and sallow. His teeth were carious, and his throat was dry. Examination of the lungs revealed fine crackles at both apexes; otherwise they were clear. The heart was not enlarged, the sounds were of fair quality, and there was a systolic murmur at the apex. The abdomen was soft and symmetrical and was not tender. On the right buttock there was a large foul-smelling ulceration extending from the upper margin of the sacrum down to the upper third of the thigh, outward to the great trochanter of the femur and inward to the anal region, along the whole length of the intergluteal fold forward to the perineum and upward in the right groin. In the upper portion the margin was irregular with rolled-in skin and moderate undermining. The region of the anus was completely undermined with a crenated margin of skin and a puckered cutaneous surface. Extending outward from the anus was an irregular area of skin with rolled-in margins and a corrugated surface. Near the anus was a hard fibrous

Fig. 1.—The lesion at the time of the patient's admission to the hospital. Note the undermined skin with its wrinkled surface and the zone of gangrene below, sharply demarcated from the living skin which is not raised. The base of the ulcer is shaggy.

nodule. At the lower margin of the lesion on the thigh and in the region extending upward in the right groin was a strip of gangrenous skin firmly adherent to the margin of living skin and fairly sharply demarcated from it. The gangrenous skin was depressed, but the living skin was not raised or purplish and there was no blush outside the area of gangrene. The lower margin of the scrotum on the right side was also undermined, and the right margin of the scrotum was gangrenous. The base of the ulcer consisted of very shaggy dusky granulation tissue covered with a foul-smelling grayish exudate (fig. 1). The patient's temperature was 101 F., the pulse rate, 100, the respiratory rate, 20, and the blood pressure 110 systolic and 70 diastolic. Analysis of the blood revealed: hemoglobin content, 25 per cent; red blood cells, 2,120,000, and white blood cells, 14,000, with polymorphonuclears, 87 per cent. The urine showed sugar (4+), acetone (4+) and diacetic acid (4+). The sugar content of the blood was 269 mg. per hundred cubic centimeters, and the carbon dioxide combining power, 49 cc. per hundred cubic centimeters.

Course.—The patient required emergency treatment to reduce the acidosis, lower the blood sugar, increase the body fluids and raise the hemoglobin content. It was thought that any operative procedure at that time would prove fatal. He was given 30 units of insulin at once, and 1,500 cc. of solution of sodium chloride by hypodermoclysis and 1,500 cc. intravenously. Orange juice (120 cc.) was given by mouth every hour. Each specimen of urine was tested for sugar, acetone and diacetic acid, and 10 units of insulin was given following a strongly positive test for sugar and 5 units after a weakly positive test. The patient improved at once and the next day he was given a fluid diet with 150 Gm. carbohydrate, 70 Gm. protein and 100 Gm. fat with insulin in three doses during the day of 15, 10 and 10 units. He was then given a transfusion of blood, and his condition steadily improved.

Diagnosis.—The history suggested the possibility of an amebic infection, and an intern made an examination of the exudate from the wound for amebas, but none were found. Examination of the stool for amebas was ordered, but through a misunderstanding it was not made at this time. A bit of tissue sent to the surgical

Fig. 2.—The wound eleven days after the operation. There had been no recurrence or spread of the infection. The granulations are active. Zinc peroxide may be seen adherent to the skin and the surface of the wound.

pathologic laboratory for examination was subsequently reported to be "loaded with amebas."

Treatment.—In the meantime the patient's general condition improved sufficiently to make us feel that it would be safe to employ surgical intervention. We felt that it was important to remove the whole mass of infected tissue as soon as possible. On the fourth day after admission, therefore, the patient was operated on and a complete excision of the lesion was accomplished. This required removing the skin of the anus, which had become completely undermined. No deep sinus tracts or fistulas were seen along the rectum. The raw surface was dressed with zinc peroxide, and in twenty-four hours the foul odor had entirely disappeared. On the third day after operation the pathologic report of the biopsy was returned and then for the first time the stools were examined for amebas. Actively motile amebas containing red blood cells, typical of E. histolytica, were found.

On the basis of these observations the patient was given a course of antiamebic treatment consisting of the daily administration of chiniofon by mouth and emetine hydrochloride by hypodermic injection over a period of two weeks.

The stools were examined on the third day after the treatment had begun and no amebas could be found. Repeated examinations thereafter gave negative results. The diabetes came under control rapidly, and the wound soon showed active granulations. Figure 2 shows the condition of the wound eleven days after operation. On the twenty-first day half the area was covered with skin grafts of the Reverdin type taken from the thigh; the rest of the wound was covered on two successive occasions: four and eleven days after the first graft. Figure 3 shows the wound nine days after the first, and five days after the second, grafting. The whole area rapidly contracted and became epitheliated, and the patient was able to leave the hospital fifty-three days after the primary operation. Ten days later the wound was fully epitheliated except for one or two small areas between grafts in the groin and intergluteal creases (fig. 4).

Bacteriologic Examination.—At the time of the operation, cultures were made of bits of subcutaneous tissue just outside the area of gangrene at the lower margin of the lesion on the thigh. Neither aerobic nor anaerobic cultures yielded any growth after prolonged incubation. Cultures of the slough beneath the gangrenous skin were overgrown with the spreader Bacillus proteus. When this mixed culture was heated for fifteen minutes at 60 C., B. proteus was killed and green aerobic streptococci survived, but no anaerobic or micro-aerophilic bacteria could be found. B. proteus was probably a casual contaminant and probably masked the presence of other bacteria both aerobic and anaerobic which succumbed to the same degree of heat.

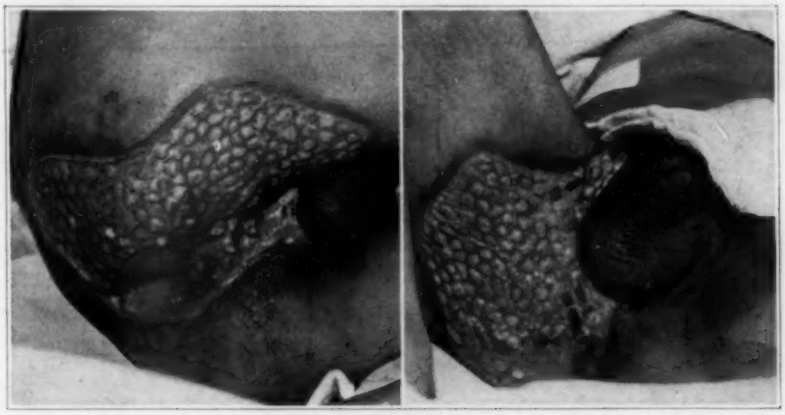

Fig. 3.—The wound nine days after the first skin graft and five days after the second graft. The first grafts have already coalesced, and the recent ones are separate.

Pathologic Study.—The tissues were studied by Dr. A. Purdy Stout and Dr. V. Kneeland Frantz of the surgical pathology department and by Mrs. Hulse and Dr. F. W. O'Conner of the department of tropical medicine of the hospital, and all agreed that the amebas were evidently playing a part in the destructive process. A thorough study of the stained sections was made and photomicrographs were prepared by one of us (H. E. M.) (figs. 5 and 6).

The histopathologic process consisted essentially of invasion of the subcutaneous connective tissue and fat by amebas with resulting histologic changes. The most striking feature of the process was a rather sharp line of demarcation

between practically normal tissue and tissue undergoing disintegration. Along this line of demarcation amebas were seen; in some places there were very few, and in others they were crowded together in large groups or in a single line (fig. 5). Some had advanced into the relatively normal tissue and others were scattered in the disintegrated tissue. The relatively normal tissue was somewhat edematous and contained mononuclear wandering cells and polymorphonuclear leukocytes in varying numbers, but never in the large numbers which are ordinarily seen in a pyogenic bacterial infection. The amebas were never very far advanced in this tissue but lay between fat cells or in tissue spaces near the line of demarcation. The disintegration consisted of fragmentation of intercellular fibers and

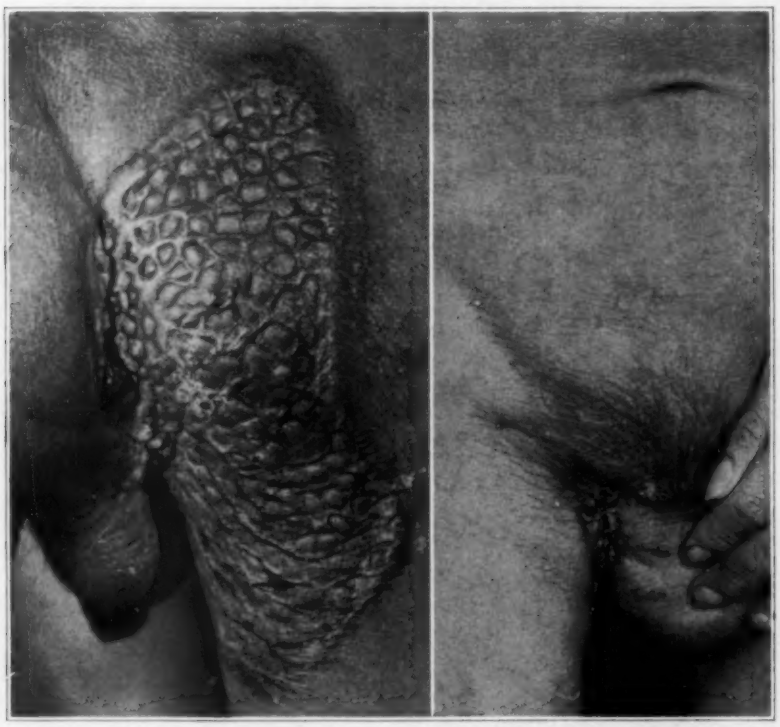

Fig. 4.—The lesion two months after the operation. The wound is completely healed except for one or two spots in the creases of the groin and buttocks. The anal mucous membrane protrudes slightly.

degeneration and nuclear fragmentation of the fixed cells and the mononuclear and polymorphonuclear cells which were present. These cells were more numerous in the disintegrated tissue than in the surrounding relatively normal tissue. Blood and lymph vessels resisted the disintegration more than the rest of the tissue. Occasionally a thrombus was found on the wall of a blood vessel adjacent to the amebic invasion (fig. 6). Amebas were also found in the lumens of some of the small veins and lymph vessels. Farther away from the line of demarcation disintegration was more complete, and blood vessels were destroyed, and at the surface of the ulcer only degenerated cellular elements and amorphous material were seen. Amebas were present in decreasing numbers as the tissue became

more disintegrated until they were practically absent at the surface of the ulcer. In one section a gangrenous condition of the tissue was present to a depth of 1 cm. or more. Amebas were not found in this area, but at the deep margin of the gangrene they were scattered along the edge of the relatively normal tissue. In another section granulation tissue was present at the overhanging edge of the epidermis, with no amebas near it, but amebas were present in the deep advancing portion of the lesion.

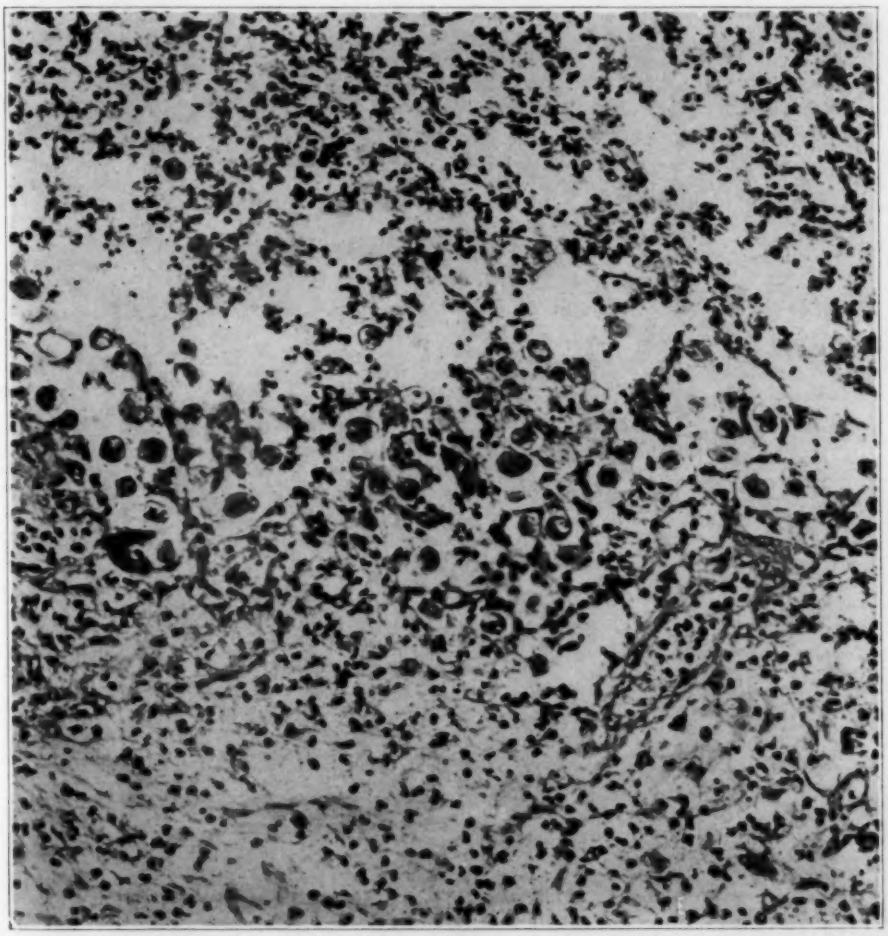

Fig. 5.—Photomicrograph showing amebas at the advancing margin of the ulcer. Note the sharp line of demarcation between the edematous normal tissue infiltrated with wandering cells (below) and the disintegrated tissue (above). Hematoxylin and eosin stain; × 230.

Gram stains for bacteria showed gram-positive cocci often in large colonies at the surface of the ulcer and in smaller colonies in the deeper disintegrated tissue, but never as deep as the amebas had advanced and never in the relatively normal tissue beyond the amebas. These cocci were small, were arranged in pairs

and short chains and had the appearance of streptococci. No gram-negative organisms could be seen. If present they must have been very few.

The impression gained from the study of these sections was that the amebas were responsible for the advance of the pathologic process and the disintegration of the tissue. The bacteria seemed to be secondary invaders growing into the already necrotic tissue.

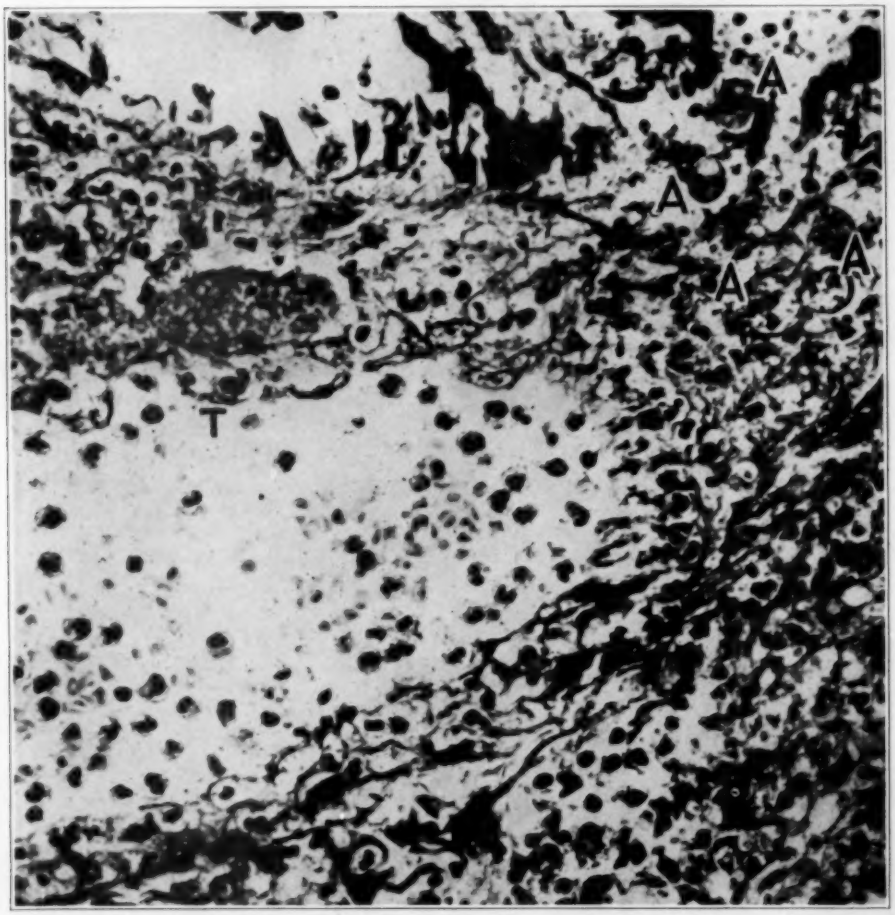

Fig. 6.—Photomicrograph showing a mural thrombus (*T*) in the lumen of a small vein in the subcutaneous tissue near the point of invasion of the amebas (*A*) into the outer layer of the wall of the vessel. Hematoxylin and eosin stain; × 500.

COMMENT

This case was of interest because of the severity of the infection and the extent of destruction of the skin. Probably the underlying diabetes increased the severity of the symptoms and had something to do with the acuteness of the process. In one of the patients whose

case was reported by M. F. Engman Jr. and one of us (H. E. M.)[10] diabetes was present, and the amebas had invaded even the striated muscle cells of the abdominal wall. In other cases previously reported the onset was more gradual and the course slower.

The condition in this case is sharply differentiated both clinically and bacteriologically from the other forms of chronic infectious gangrene. The differentiation is particularly important between this type and progressive postoperative synergistic gangrene.[18] In that disease the dead skin and subcutaneous slough are adherent all around the margin of the lesion. There is no undermining of the edges of the skin. The outer margin of the gangrene is crenated. The skin outside the gangrene is raised from the surface and is purplish, and this zone is surrounded by a brilliant red zone from 1 to 3 cm. wide which gradually fades off into normal skin. The lesion is excruciatingly tender. In the case reported here there was relatively little gangrene of the skin and the line of demarcation was relatively smooth and sharply outlined, the margin of skin outside the gangrene was not raised, there was no red zone, and the wound was not extremely tender. The margin of the skin elsewhere was extensively undermined and the granulating base of the ulcer was rough and shaggy with necrotic tissue adherent to it.

Although in the present case the clinical appearance of the lesion was quite different from that which we have seen in cases of postoperative synergistic gangrene, other cases of amebic ulceration of the skin may not be so distinctive in their clinical appearance. For example, in the two cases reported by M. F. Engman Jr. and one of us (H. E. M.)[10] an advancing red zone about the ulcers was described, and in one patient the margin of the ulcer was raised and acute tenderness was noted. In some cases of bacterial gangrene amebas may be present as contaminating organisms without taking part in the gangrenous process. In other cases both factors may operate and change the characteristic clinical picture accordingly.

The bacteriologic study confirmed this differentiation, for in the synergistic type of gangrene the essential organism, a micro-aerophilic nonhemolytic streptococcus, may always be found in pure culture of material from the area just outside the margin of the gangrene and is associated with Staphylococcus aureus in the gangrene. While B. proteus may be a secondary contaminant of any wound from fecal soiling, it may be destroyed by heating to 60 C. for fifteen minutes, while the streptococcus survives. In this case not only were we unable to cultivate this streptococcus from material in the zone outside the gangrene, but

18. Meleney, F. L.: Bacterial Synergism in Disease Processes, with Confirmation of the Synergistic Bacterial Etiology of a Certain Type of Progressive Gangrene of the Abdominal Wall, Ann. Surg. **94**:961, 1931; footnote 1.

we failed to find it in the gangrenous area itself. The pathologic study likewise confirmed this, for the amebas were found in the advanced zone of infection while the bacteria were in the rear. We cannot be sure, however, that the amebas were not aided by the presence of the bacteria, for we know that cultivation of amebas in vitro without bacteria is at present impossible.

SUMMARY

A case of gangrene of the buttocks, perineum and scrotum has been studied from clinical, bacteriologic and pathologic standpoints, and the conclusion has been reached that it was due primarily to the lytic action of E. histolytica.

As far as we know, this is the first case that has been studied carefully with anaerobic bacteriologic technic, thus ruling out the presence of the micro-aerophilic nonhemolytic streptococcus which is the essential organism in the progressive postoperative synergistic gangrene with which this disease might be confused. The differential features of these two diseases have been outlined.

The patient made a rapid recovery following the complete excision of the lesion, the administration of a course of chiniofon and emetine hydrochloride, the local application of zinc peroxide and the application of skin grafts.

LUMBAR VERTEBRAL EPIPHYSITIS

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NEW YORK

For a number of years physicians have recognized the existence in adolescent youths of a disturbance in the epiphyseal rings of the vertebral bodies due to nutritional inadequacy and rapid growth. The condition has been designated, for convenience, vertebral epiphysitis; its clinical appearance and the roentgenographic evidence of pathologic changes are similar to the syndrome occurring in other epiphyses, notably in the head of the femur, the tibial tubercle, the tarsal scaphoid and other similar structures. Vertebral epiphysitis, described by Scheuerman, Buchman and others, has a clinical syndrome which is readily recognized. In brief, the patient, a boy or girl in the early teens, usually without any apparent cause or at times after a seemingly minor trauma, experiences pain in the middorsal area of the back and tires easily. Objectively he presents an abnormal degree of rounding of the back and tenderness to pressure over the dorsal portion of the spine. The roentgenograms show an involvement of from six to eight vertebrae in the middorsal section. There are haziness and reduction in the size of the intervertebral spaces. There is a loss of definition of the outlines of the vertebral bodies. The superior and inferior surfaces are wavy. Frequently there is marked wedging of the vertebrae. This condition continues for some time, but it is self-limited in that toward the end of puberty or within several years of the onset the process terminates, the pain, tenderness and fatigue disappearing more or less completely. But this pathologic condition may, when it gives rise to vertebral wedging, set up a rigid posterior curvature of the spine which may be difficult or even impossible to correct. Buchman expressed the belief that dorsal vertebral epiphysitis may even initiate and be responsible for structural scoliosis.

An interesting and as yet not satisfactorily explained peculiarity of vertebral epiphysitis, of which one sees many instances nowadays, is that it occurs mainly in the dorsal region. My colleague, Dr. Buchman, has seen several cases of epiphysitis of the lumbar vertebrae. The case herein reported is the first one to come under my personal observation and is interesting for several reasons which will be apparent in the clinical detail.

REPORT OF A CASE

R. B., aged 12 years, came under my care in November 1931. The chief complaints were pain in and stiffness of the lower portion of the back, pain in the thighs, fatigue and inability to engage in vigorous physical exercise. There was no history of trauma. The examination showed that the lad had been growing rapidly and was apparently in good general condition. The posture was poor. The patient presented a moderate degree of dorsolumbar posterior curvature and a slight deviation of the lumbar portion of the spine to the right side. There was

Fig. 1.—Roentgenogram taken in the lateral position, showing the lumbar portion of the spine (November 1931). All the lumbar vertebrae are affected, but the first, second and third show the greatest change. There are rarefaction and some apparent loss of bony substance in the anterior portions of the bodies. The fourth lumbar vertebra has a wavy, somewhat indefinite outline. The intervertebral spaces are not altered.

fairly marked tenderness to pressure over the lumbar portion of the spine and marked limitation of all lumbar movements. Roentgenograms taken in the anteroposterior position showed a mild lumbar scoliosis to the right side. Those taken in the lateral position showed marked changes in all the lumbar vertebrae but the last. These changes consisted of areas of apparent erosion and absorption (fig. 1). The erosion or irregular rarefaction affected the superior anterior por-

tions of the first and second lumbar vertebrae but was especially marked in the third lumbar vertebra. The fourth and fifth vertebrae seemed to have unduly long anteroposterior diameters and appeared somewhat compressed from above downward. The dorsal vertebrae appeared normal.

A diagnosis of advanced lumbar vertebral epiphysitis with secondary scoliosis was made, and a plaster of paris jacket was applied. The boy was allowed to go

Fig. 2.—Roentgenogram taken in the anteroposterior position (March 1934). There is a mild scoliosis to the right side in the lumbar portion of the spine with a slight compensatory curve to the left in the dorsal portion. Note the wedging of the second and third lumbar vertebrae.

to school, but gymnastic exercises and all strenuous physical activity were interdicted. These instructions were not continuously followed; on many occasions the patient played baseball and ran in races, two types of sport in which he excelled. In January 1932, the plaster jacket applied two months previously was

removed. The condition of the back had improved. The backache and spinal tenderness had disappeared. The posterior curvature seemed corrected. The roentgenograms showed favorable progress; the craters in the vertebral bodies were smaller, and there was definite calcification and ossification of the rarefied areas. A Taylor spinal brace was provided. The patient was reexamined six months later, in June 1932, when he showed signs of continued improvement clin-

Fig. 3.—Roentgenogram taken in the lateral position (March 1934). The conformation of the vertebral bodies is nearly normal. The area of bone absorption has almost completely disappeared. The crater in the third lumbar vertebra has filled in. The outlines of the vertebrae are more clear. These evidences indicate recession of the pathologic condition and healing.

ically and roentgenographically. Examinations of the blood for the phosphorus, calcium and phosphatase contents gave normal results. He returned thirteen months later, in July 1933, stating that he felt well, had been quite active and had engaged freely in sports without becoming fatigued. The roentgenograms showed seem-

ingly progressive improvement in the conformation and structure of the lumbar vertebrae. But clinically there had been retrogression; the boy's posture was again poor, and there was recurrence of the posterior curvature and tenderness of the lumbar portion of the spine. The possibility of the deformity's increasing was explained to him, and caution was advised. He was provided with a new spinal brace to be worn during the day and with a convex frame on which he was to sleep.

I saw this boy again in March 1934, eight months after the previous visit. During the interval he had grown unusually tall. His mother thought that he had grown about 5 inches (13 cm.). He certainly had completely outgrown the brace. He complained of pain, stiffness and weakness in the back. The examination showed that he had not only a posterior curvature of the spine but a definite lateral curvature to the right side, that is, a lumbar kyphoscoliosis to the right side. Flexion of the spine was almost completely restricted. Hyperextension and lateral inclination were only slightly limited.

In the roentgenogram taken in the anteroposterior position at that time (fig. 2) the second and third lumbar vertebrae appeared wedge-shaped. There was a mild curve to the right side in the lumbar portion, and a compensatory curve to the left in the dorsal portion of the spine. A roentgenogram taken in the lateral position (fig. 3) showed an improvement in the epiphyseal changes. There was almost complete restoration of the normal conformation of the vertebrae, with decided diminution of the rarefaction and increased ossification. The first lumbar vertebra showed only a slight defect in the upper anterior corner. There was decided increase in the density of the bone in the upper and lower surfaces of the second lumbar vertebra; the crater-like formation in the third lumbar vertebra had disappeared and was replaced by a moderate amount of rarefaction in the upper surface of the body of that vertebra. The outline of the third lumbar vertebral body was practically normal. The fourth lumbar vertebra showed some waviness and rarefaction of its upper surface. The intervertebral spaces were clear and free from any bony projections. This roentgenogram when compared with the first one made two and a half years before showed a marked change for the better in the structure of the lumbar vertebrae, although clinically the boy was far from well. A plaster of paris jacket was immediately applied to correct the kyphoscoliosis and provide rest for the back. I had learned by then that this boy's activity could be controlled or restricted only by a mechanical hindrance such as a plaster jacket. His promise to rest could not be relied on. In July 1934 the patient had no pain and no spinal tenderness. He still had stiffness of the back. He was wearing a spinal brace and taking regulated gymnastic exercises to improve the muscle tone and to increase the mobility of the spine.

DIFFERENTIAL DIAGNOSIS

In arriving at a diagnosis of this patient's lesion there were, from a practical standpoint, only two conditions to consider, namely, Pott's disease and osteochondritis. If the condition had been tuberculosis of the spine the history would have indicated and the examination would have revealed greater disability. Moreover, the roentgenograms would have shown irregular destruction and absorption of bone, disappearance of the intervertebral cartilage, formation of an angular deformity or gibbus and possibly one or more cold abscesses and evidences of pressure on the spinal cord. In tuberculosis when several vertebrae are involved in an extensive destructive process the central vertebra dis-

appears partially or totally and the adjacent vertebrae above and below it become approximated. The absence of all these findings permitted an unqualified exclusion of the diagnosis of tuberculosis of the lumbar portion of the spine.

In osteochondritis of a vertebrae, as the literature indicates, there is usually involvement of only one vertebra which is widened in its transverse and reduced in its vertical diameter. The superior and inferior epiphyseal plates are practically unchanged. In epiphysitis and in the case here reported the essential pathologic change is in the epiphyseal plates and not in the substance of the body. Consequently it was reasonable to eliminate the diagnosis of osteochondritis.

COMMENT

In retrospect it appears that a more favorable result would have been obtained if, when the diagnosis of vertebral epiphysitis was established, I had insisted on rigid and continuous support of the spine by a brace during the day, avoidance of all strenuous physical activity and competitive games and the use of a convex frame at night. By such measures the process of epiphyseal dysfunction may have been aborted, ossification hastened and the scoliosis possibly prevented. The more cases of epiphyseal growth disturbances I study and the more patients I treat, the more I am convinced that rest to the affected part is the most effective therapeutic agent. In parts of the body other than the spine, I have been able to combat epiphysitis by enforced rest and have succeeded in obtaining rapid and complete cures. In epiphyseal disturbances of the spine occurring during the period of growth, abstinence from weight bearing, as nearly complete as possible, is the essential requirement in the therapeutic program.

SUMMARY

A case of lumbar vertebral epiphysitis in an adolescent boy is reported.

The changes observed roentgenographically are similar to those seen in dorsal vertebral epiphysitis and are fairly characteristic of this condition.

The patient has been observed for nearly three years. During this time the pathologic changes in the bones have retrogressed, but a mild lumbar kyphoscoliosis has appeared.

The subjective symptoms of pain in and weakness of the back and fatigue were easily controlled by mechanical supports.

The changes in the vertebral epiphyses are undoubtedly due to nutritional inadequacy arising from inordinately rapid growth.

This case is of special interest because vertebral epiphysitis rarely affects the lumbar vertebrae.

SURGICAL TREATMENT OF EPENDYMAL GLIOMA OF THE SPINAL CORD

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AND
GEORGE H. PATTERSON, M.D.
LOS ANGELES

Tumors of the central nervous system having their origin from ependymal cells have long been looked on as a rarity. The reports of workers in the various clinics, particularly of those interested in tumors of the brain, reveal but a relatively small number of ependymal gliomas found in the encephalon. In 1926 Bailey and Cushing [1] reported 7 ependymomas among 254 classified gliomas. In a later study Bailey [2] found 16 ependymal tumors during an analysis of 566 gliomas. Fincher and Coon [3] in 1929 reviewed 8 cases found among 140 cases of glioma at the Sachs clinic. The ependymomas, therefore, would seem to comprise but a small percentage of the glioma family as found in the brain.

The careful investigations of Kernohan, Woltman and Adson [4] have revealed a different situation with regard to the number of ependymal tumors found as intramedullary tumors of the spinal cord. In an analysis of 51 verified intramedullary tumors of the spinal cord these authors found 21 ependymomas, or an incidence of 42 per cent, which would seem to place this group among the common parenchymatous tumors of the spinal cord.

LITERATURE

Two communications by Bailey [5] which appeared in 1924 and 1925 furnish a complete summary of the pathologic picture presented by

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Read before the section on Neuropsychiatry at the Sixty-Third Annual Session of the California Medical Association, May 2, 1934.

From the Neurosurgical Service of Dr. Carl W. Rand and Dr. George H. Patterson, Los Angeles County General Hospital, and the Department of Neurological Surgery, University of Southern California, School of Medicine.

1. Bailey, Percival, and Cushing, Harvey: A Classification of the Tumors of the Glioma Group, Philadelphia, J. B. Lippincott Company, 1926, p. 175.

2. Bailey, P.: Further Remarks Concerning Tumors of the Glioma Group, Bull. Johns Hopkins Hosp. **40**:354 (June) 1927.

3. Fincher, E. F., and Coon, G. P.: Ependymomas: A Clinical and Pathologic Study of Eight Cases, Arch. Neurol. & Psychiat. **22**:19 (July) 1929.

4. Kernohan, J. W.; Woltman, H. W., and Adson, A. W.: Intramedullary Tumors of the Spinal Cord, Arch. Neurol. & Psychiat. **25**:679 (April) 1931.

5. Bailey, P.: A Study of Tumors Arising from Ependymal Cells, Arch. Neurol. & Psychiat. **11**:1 (Jan.) 1924; Quelques nouvelles observations des tumeurs ependymaires, Ann. d'anat. path. **2**:481 (Nov.) 1925.

gliomas of ependymal origin. On further review one finds numerous references with excellent descriptions of these tumors. The classic description by Saxer [6] appeared in 1902 and was followed shortly by Mallory's [7] important paper describing 3 ependymal gliomas. The importance of the latter contribution lies in the fact that Mallory actually demonstrated the origin from ependymal cells of the tumors in his 3 cases. Spiller [8] reported 2 extremely interesting cases in 1903 and 1907, in 1 of which he regarded the growth as a spinal metastasis from a typical growth in the fourth ventricle. Penfield's [9] résumé of the ependymal tumors is clear and concise and furnishes common ground for the descriptions given by Roussy, Lhermitte and Cornil,[10] and Roussy and Oberling [11] in their monographs on a group of gliomas under the term ependymoglioma. Orlandi [12] in 1925 and Silberberg [13] in 1926 described single cases, and at about the same time appeared the paper of Hirsch and Elliot [14] with a report of 2 additional cases, in each of which the tumor arose in the lateral and fourth ventricles.

The ependymomas are situated most frequently in the posterior fossa near the midcerebellar region, probably arising from the roof of the fourth ventricle and many times growing down through the foramen magnum. In one of Spiller's [8a] cases the tumor grew down from the fourth ventricle to the level of the sixth cervical vertebra. In 5 of the Fincher-Coon [3] series of 8 cases the tumor was located in the cerebrum close to the lateral ventricles and, as the authors indicated, there was no predilection for any particular portion of the lining of the lateral ventricles as a site of origin.

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6. Saxer, F.: Ependymepithel, Glioma und epithiale Geschwülste des Centralnervensystems, Beitr. z. path. Anat. u. z. allg. Path. **32**:276, 1902.

7. Mallory, F. B.: Three Gliomata of Ependymal Origin: Two in the Fourth Ventricle, One Subcutaneous Over the Coccyx, J. M. Research **8**:1 (June) 1902.

8. (*a*) Spiller, W. G., and Hendrickson, W. F.: A Report of Two Cases of Multiple Sarcomatosis of the Central Nervous System and One Case of Intramedullary Primary Sarcoma of the Spinal Cord, Am. J. M. Sc. **126**:10 (July) 1903. (*b*) Spiller, W. G.: Gliomatosis of the Pia and Metastasis of Glioma, J. Nerv. & Ment. Dis. **34**:298 (May) 1907.

9. Penfield, Wilder: Principles of the Pathology of Neurosurgery, in Nelson Loose-Leaf Living Surgery, New York, Thomas Nelson & Sons, 1927, vol. 2, chap. 6, p. 303.

10. Roussy, G.: Lhermitte, J., and Cornil, L.: Essai de classification des tumeurs cérébrales, Ann. d'anat. path. méd.-chir. **1**:333, 1924.

11. Roussy, G., and Oberling, C.: Atlas du cancer, Paris, Felix Alcan, 1931.

12. Orlandi, H., quoted by Bailey,[2] p. 375.

13. Silberberg, E.: Neuroblastoma und Neuroepithelioma, Virchows Arch. f. path. Anat. **260**:251, 1926.

14. Hirsch, E. F., and Elliot, A. R.: Ependymomas of the Lateral and Fourth Ventricles of the Brain, Am. J. Path. **1**:627, 1925.

The frequency with which these tumors arise primarily in the spinal cord has never been stressed, nor has their surgical accessibility been generally recognized. Bickel,[15] Jumentie,[16] Holmes and Kennedy [17] and Dejerine and Jumentie [18] have reported cases of ependymal tumor arising in the spinal cord. Cases of tumor with a similar origin described under the term neuro-epithelioma have been cited by Rosenthal,[19] Kling,[20] Schlapp [21] and others, which would indicate that the spinal cord is not an uncommon locus of origin. Perhaps the most interesting individual report of a case is the one by Cushing,[22] whose graphic description bears quotation since it clearly visualizes the technical problems involved in the removal of such a tumor.

The patient, an 8 year old girl, was referred to the clinic of the Peter Bent Brigham Hospital on Sept. 8, 1926, with a diagnosis of possible syringomyelia. The history was essentially as follows:

"In October 1924, she complained of a stiff neck and had a temporary 'torticollis.' After eight weeks of treatment by a local physician at her home she gradually recovered, and remained well until September 1925, when she had a recurrence of the 'torticollis' with pain in the neck. She nevertheless was able to attend school at irregular intervals during the ensuing school year. In July 1926, after several chiropractic treatments there was an increase in symptoms with a distinct change in the condition—more severe pain and muscular weakness of the arms. Doubtless under the suspicion that she had cervical Pott's disease, a local surgeon had her wear a Thomas collar.

"The most striking thing, objectively, on admission was the curious fixed and rigid position in which she held her head. Any attempt to change this position caused pain. There was an exaggeration of the deep reflexes, muscular weakness of both upper extremities with considerable atrophy, particularly marked in the intrinsic muscles of the hands. There was thought to be some dissociation of sensation, but the sensory symptoms were exceedingly slight and variable. The differential diagnosis lay between cervical Pott's disease (though there were no

15. Bickel, M. G.: Contribution á l'étude des tumeurs de la moelle épinière et de la syringomyélie, Ann. de méd. **10**:253 (Oct.) 1921.

16. Jumentie, J.: Tumeur de la moelle lombo-sacrée et formations glieuses du type syringomyélique, Rev. neurol. **34**:741 (Dec.) 1927.

17. Holmes and Kennedy: Syringomyelia Without Symptoms Associated with Intracranial and Spinal Tumors, Proc. Roy. Soc. Med. **2**:4, 1908.

18. Dejerine, J., and Jumentie, M. J.: Tumeur intramedullaire de nature complexe, Rev. neurol. **37**:1138 (Nov. 3) 1921.

19. Rosenthal, W.: Ueber eine eigentümliche mit Syringomyelie complizierte Geschwulst des Rückenmarks, Beitr. z. path. Anat. u. z. allg. Path. **23**:111, 1898.

20. Kling, C. A.: Ein Beitrag zur Kenntnis der Rückenmarkstumoren und Höhlenbildungen im Rückenmark, Ztschr. f. klin. Med. **63**:322, 1907.

21. Schlapp, M. G.: Neuro-Epithelioma Developing from a Central Gliosis, After an Operation on the Spinal Cord, J. Nerv. & Ment. Dis. **38**:129 (March) 1911.

22. Cushing, H.: The Intracranial Tumors of Preadolescence, Am. J. Dis. Child. **33**:551 (April) 1927.

bony lesions shown by the roentgen ray), syringomyelia and tumor of the cord. Each of these diagnoses had its firm supporters. . . .

". . . I went ahead with a cervical laminectomy, which, before the end, was extended so as to include all of the cervical and the two upper thoracic vertebrae.

"An extraordinary condition was found. The canal . . . was greatly distended, so that the flattened laminae were removed easily, giving an unusually wide exposure. When the dura was opened and reflected, no fluid was secured, and a bulging cord presented. One could see through the thinned nervous tissue that there was a central tumor. A longitudinal incision, the length of the entire wound, through the greatly thinned posterior columns, disclosed a central soft reddish tumor mass which began spontaneously to extrude itself. With a 'sucker,' it was cleanly removed, leaving a widely dilated, thinned out gutter of nervous tissue.

"I can only liken the procedure to the splitting of an over-ripe banana with the removal by suction of its central fruit, leaving the collapsed skin behind. The upper pole of the tumor was at the level of the foramen magnum, and not until this portion of the growth was removed did cerebrospinal fluid begin to find its way down into the gutter. The lower pole of the tumor extended below the second thoracic level, and it was thought wise to postpone further measures for a second session.

"The tumor, which presumably extends much further down the cord, proves to be an ependymoma and has therefore arisen from the central canal. Now that she has made such an excellent recovery we propose to laminectomize the remainder of the spine and to clean out what remains of the lesion in the lower levels, for it fortunately is a relatively benign type of glioma and is not infiltrative in character.

"*Subsequent Note.*—The second laminectomy exposing the remainder of the cord from the second thoracic to the second lumbar vertebrae inclusive was carried out on November 2. When the cord was exposed I found to my surprise that the tumor ended at about the second thoracic level with nothing below but a marked hydromyelia. The patient was discharged on November 27, walking, with free cervical movements, return of function in her hands, and little to show for her former trouble except overactive reflexes."

A rather unusual type of surgical removal for this kind of tumor was used in this case, since the majority of these neoplasms are quite firm and encapsulated and may be separated from the spinal cord only by gentle blunt dissection. The association with hydromyelic or syringomyelic cavities is almost a constant finding in cases of tumor of this type, and according to Dowman and Smith [23] such cysts suggest the presence of an intramedullary tumor.

PATHOLOGY

The ependymal gliomas have passed through many phases in the gradual evolution of a rather confusing nomenclature. Formerly the

23. Dowman, C. E., and Smith, W. A.: Intramedullary Cyst of the Spinal Cord Associated with a Circumscribed Intramedullary Tumor, Arch. Neurol. & Psychiat. **21**:582 (March) 1929.

terms neuro-epithelioma, ependymoblastoma and ependymoglioma were given to one and the same type of tumor. The subdivisions of the family group into ependymoblastoma and ependymoma have been recognized as being mainly transitional forms, and the characteristics of the two groups differ little. At present an ependymoma is considered in simple terms to be that type of glioma which enters into the formation of ependymal epithelium, and its general family name has been simplified by the use of the term ependymal glioma or ependymoma. This tumor seems by structure to be derived from the ependymal lining of the cerebral ventricles and spinal canal. The tumor is usually rather firm, encapsulated and sometimes nodular and shows tendencies to undergo calcification and the formation of cysts. In the spinal cord the

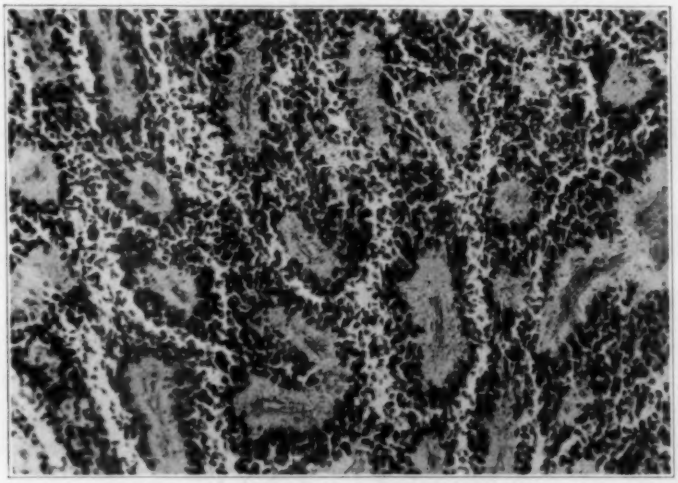

Fig. 1.—A section of an ependymal glioma (ependymoblastoma), showing the formation of pseudorosettes about small blood vessels. Hematoxylin and eosin stain; × 95.

origin, as indicated, is from the ependymal lining of the central canal, the tumor being very slow growing and gradually producing the signs and symptoms of an intramedullary neoplasm.

Microscopically these tumors are very cellular. They are characterized by an array of cells about blood vessels to form pseudorosettes. Between the nuclei of the cells and the walls of the central blood vessel is a clear zone occupied by the tail-like processes. There is but little free fat, but the connective tissue about numerous well formed blood vessels gives the appearance of a stroma. Calcification is occasionally found in the central portions of the tumor. Mitotic figures are usually not seen. Mallory [7] stressed as a peculiar and characteristic feature of ependymal cells the cytoplasmic granules or rods previously described by Weigert. He discovered such structures in the neoplastic cells and

concluded that in new growths of ependymal origin such granules or markings (blepharoplasts) would be found. These cytoplasmic markings are, therefore, a useful diagnostic finding, as blepharoplasts are to be found only in ependymal cells and, according to Horrax and Bailey,[24] in pineal cells. The specific methods of staining with metals, such as the Hortega silver carbonate (lithium) stain,[3] serve to bring out the fine detail necessary to establish the relationship of the various neoplastic elements to embryonic forms as found in the histogenesis of normal nerve tissue. The cytoplasm is particularly well demonstrated with Bailey's ethyl violet-orange G and with Mallory's phosphotungstic acid and hematoxylin stain. However, these tumors may be identified as routine with the hematoxylin and eosin stain [25] which reveals clearly the characteristic tissue architecture and nuclear detail (fig. 1).

SURGICAL ASPECTS

The pioneer work of Kernohan and his associates [4] has added encouragement to study of the problem of the intramedullary gliomas of the spinal cord of ependymal origin. The realization that this type of glioma is relatively common, has benign tendencies, and in many cases is surgically accessible has led to a careful reconsideration of what has long been looked on as a practically hopeless situation. Foerster,[26] Elsberg,[27] Frazier [28] and many others have reported good results from the removal of tumors of the spinal cord of intramedullary origin. The more recent efforts have been along conservative lines and with good reason. The spinal cord withstands manipulation poorly, and rough handling during the surgical procedure involved in the removal of a neoplasm, not only may leave the patient completely paralyzed afterward but in the upper thoracic and cervical levels may cause early death by respiratory failure or by fatal hyperthermia. In 1911 Elsberg and Beer [29] originated the so-called "extrusion method" for the removal of intramedullary tumors. This method entails a two stage operation. At the first session the tumor is located by incising the posterior columns, and at the second operation as much of the tumor as has extruded

24. Horrax, G., and Bailey, P.: Pineal Pathology, Arch. Neurol. & Psychiat. **19**:394 (March) 1928.

25. Courville, C. B., and Adelstein, L. J.: Tumors of the Glioma Group—Their Histologic Diagnosis, California & West. Med. **34**:396 (June) 1931.

26. Foerster, C.: Zur Diagnostik und Therapie der Rückenmarkstumoren, Deutsche Ztschr. f. Nervenh. **70**:64, 1921.

27. Elsberg, C. A.: Tumors of the Spinal Cord, New York, Paul B. Hoeber, Inc., 1925.

28. Frazier, C. H.: Surgery of the Spine and Spinal Cord, New York, D. Appleton & Company, 1918, p. 584.

29. Elsberg, C. A., and Beer, E.: The Operability of Intramedullary Tumors of the Spinal Cord, Am. J. M. Sc. **142**:636, 1911.

itself is removed. By this method minimum injury to the cord itself is produced. This technic has found favor in many hands and is the method of choice for the removal of tumors which are soft, infiltrating and with little or no line of demarcation. Others, like Jonesco-Sisesti [30] who reviewed 19 cases of intramedullary tumor associated with syringomyelic cavities, believe that surgical measures for intramedullary tumors should be limited to decompressive laminectomy followed by roentgen therapy. In 1931 Cairns and Riddoch [31] reported the successful removal of ependymal glioma of the spinal cord in 2 patients, in 1 of whom the tumor was located in the cervicothoracic region and in the other, in the thoracic portion, of the spinal cord. Both tumors were completely removed with good results. Their technic is one closely following that of Elsberg which appeared some years ago and which we feel will bear revival at this time.

During the past two years, 2 patients with ependymal tumor of the spinal cord have been seen in this clinic. Both have come to operation, and it is felt that a report of their cases in full is warranted because the cases emphasize the pitfalls in diagnosis as well as the many details and scrupulous care necessary in the successful handling of patients with intramedullary tumors. In agreement with Cairns and Riddoch it must be recognized that the need for meticulous and painstaking aftercare is of paramount importance in cases of this type.

REPORT OF CASES

CASE 1.—*Intramedullary ependymoma of cervicothoracic portion of spinal cord. Complete removal in one stage operation. Marked improvement.*

History.—M. I., a white man 25 years old, a millinery operator, referred by Dr. David Rosenblum, Los Angeles, was first seen in January 1932, with a complaint of numbness and tingling in the right leg followed by progressive weakness of the limb. These symptoms were first noticed in November 1931. Three weeks after the onset the patient noticed that he dragged the right leg in walking and that the right hand and arm were also becoming weak. This was followed within a short time by a similar progression of symptoms in the left arm and hand. Examination in January 1932 revealed horizontal nystagmus, marked intention tremor and absence of abdominal reflexes, on the basis of which the tentative diagnosis of multiple sclerosis was based. The patient then returned to his work as a millinery operator until May, by which time there had developed marked weakness with atrophy of the small muscles of both hands. However, he could still walk about, though with difficulty, and at no time was there any bladder disturbance. Constipation had been marked for some six months prior to his admission to the Los Angeles County General Hospital on June 29.

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30. Jonesco-Sisesti, N.: Tumeurs medullaires associées à un processus syringomyélique, Paris, Masson & Cie, 1929.

31. Cairns, H., and Riddoch, G.: Observations on the Treatment of Ependymal Gliomas of the Spinal Cord, Brain **54**:117, 1931.

Examination.—The pupils were small, regular and approximately equal and reacted fairly well to light and in accommodation. There were many nystagmoid jerks on looking to the right. These were not considered to be definite nystagmus. The optic disks were well outlined. The nerve heads appeared rather paler than normal. The remainder of the cranial nerves were carefully examined and found to be within normal limits.

There were marked weakness and atrophy with almost complete loss of grip in both hands; the right arm and hand were much more involved than the left. The lower extremities were very weak—the right leg could scarcely be raised off

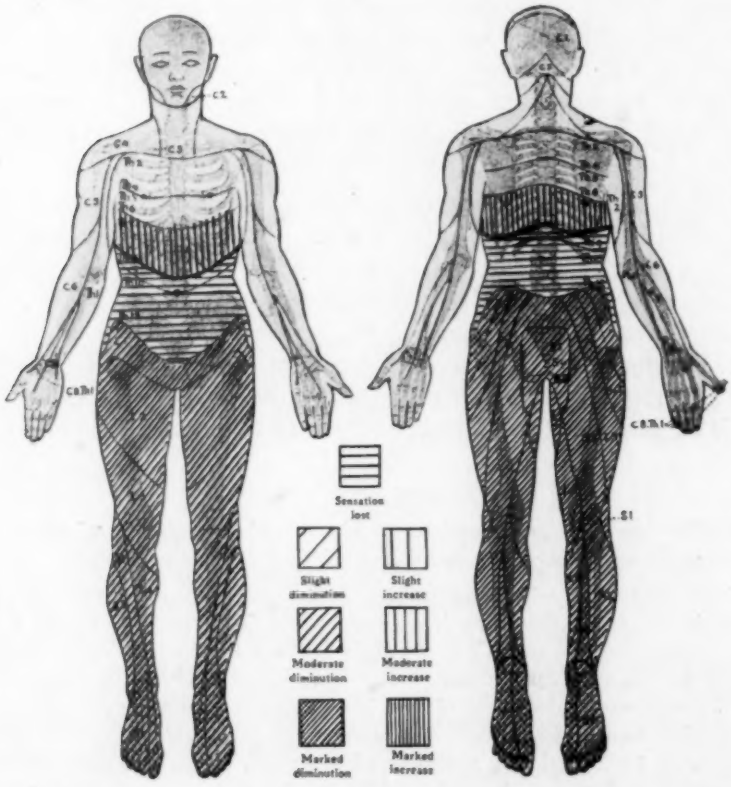

Fig. 2 (case 1).—A diagram showing the cutaneous sensory disturbances in a patient with an intramedullary tumor at the sixth cervical segment.

the bed; the left leg was a little stronger but also presented marked muscular weakness. The deep reflexes were generally increased with the exception of those in the upper extremities. The biceps and triceps reflexes were very weak, particularly on the right. The abdominal and cremasteric reflexes were absent. The knee jerks were markedly increased and there were bilateral ankle clonus and Babinski, Gordon and Oppenheim signs.

There was a sensory level at the sixth cervical segment below which perception of light touch was practically absent (fig. 2). Position sense was completely lost in the right toes, foot, ankle and knee and was only fair in the left lower extremity.

In both the upper and the lower limbs sensation of hot and cold was difficult to differentiate. Vibration sense was completely absent as high as the fifth dorsal segment. On only one occasion did the patient complain of severe pain shooting down both arms. This occurred on his trying to get into bed after taking a short walk. It was thought that the sensory picture was generally that of an atypical Brown-Séquard syndrome with greater sensory symptoms on the right side than on the left.

Roentgen examination of the cervical portion of the spine revealed no characteristic pathologic change, particularly no evidence of bony involvement. The cervical portion of the spine was not tender on palpation. Examination of the spinal fluid revealed a small amount of slightly xanthochromic fluid with an initial pressure of 190 mm. There was no rise in pressure following bilateral jugular compression. There were 24 lymphocytes per cubic millimeter, and the globulin content was markedly increased.

Diagnosis.—At this time there was conclusive evidence of a probable neoplasm of the spinal cord, having its upper limit at approximately the sixth cervical segment. The almost complete absence of irritation of the roots and the difficulty in recognizing hot and cold suggested a neoplasm of intramedullary origin. The preoperative suggestion, however, was endothelioma on the right side of the cord.

Operation.—An incision was made from the sixth cervical to the first dorsal vertebra and wide laminectomy was performed. The dura was opened with a longitudinal incision, and a dry pulseless tumor was found at the level of the seventh cervical vertebra. The mass was reddish, soft and friable and apparently had an intramedullary point of origin. It became apparent at this point that a larger approach would be necessary, so the fifth cervical spinous process was removed and its corresponding laminae. With careful blunt dissection the superior surface of the tumor was gently dislocated from its surrounding bed of cord substance (fig. 3). Multiple sutures placed through the tumor provided the necessary traction to hold the neoplasm gently and enabled the surgeon to tilt the superior pole of the mass away from the cord. By gently continuing blunt dissection the entire mass, perhaps 5.5 cm. in length, was removed. The vascular pedicle was secured with silver clips and divided. The appearance of the spinal cord after removal of the tumor was that of a thin cuff of nerve tissue with a deep central gutter. The dura was left unclosed in order to provide sufficient decompression for any postoperative edema of the cord. The wound was then carefully closed in layers with no. 2 chromic catgut for the muscles and fascia and black silk for the subcutaneous and cutaneous layers. The condition of the patient at the end of the operation was fair. Ether anesthesia was used throughout the session.

Postoperative Course.—The immediate effects of surgical intervention were disconcerting, as quadriplegia with involvement of both sphincters appeared to have been produced and it was feared that the surgical trauma had probably completed the picture begun by the tumor. However, the patient began a slow but definite improvement. The postoperative course was further complicated by severe cystitis, but this gradually subsided. The wound healed well, and the patient was discharged to his home on September 13.

For the first day after the operation the pulse rate remained at an average of 120, returning gradually to 90 within five days. The temperature rose to 101.5 F., at which point it fluctuated for about ten days. Motor and sensory power were completely absent for almost two weeks. On the sixteenth day the legs and fingers could be moved slightly, and on the same day the patient voided spontaneously. From this date improvement was progressive. Changes in sensation

took place very slowly. Physical therapy was instituted early and the patient was closely observed in the neurologic outpatient department. By November 15 the patient had gained 25 pounds (11.3 Kg.) and had full control of both sphincters. The grips were good, and he was attempting to walk with fair results. On Jan. 10, 1933, the patient was walking with the aid of crutches. On April 4 he was walking with the aid of a cane. No definite sensory level could be determined. Muscular strength was good, and the grips were excellent. The reflexes generally were hyperactive, being greater on the right, with no pathologic reflexes. In June 1933,

Fig. 3 (case 1).—A drawing showing the condition found at operation, during which the tumor was removed at one session.

scarcely a year after the operation, the patient was walking about without aid and apparently was in excellent condition. In September he was considering the possibility of returning to his work as a millinery operator in a local factory. It is felt that the ultimate result in this case will be satisfactory and that the patient may become a self-supporting and able citizen.

Pathologic Examination.—The tumor (fig. 4) measured 5.8 by 2.1 by 1.8 cm. in its greatest diameters. It appeared to be encapsulated, with a smooth outer surface, and tapered somewhat at its lower pole. It was rather firm in structure, although with a rather fluctuant feel in the upper portions. The cut section revealed soft yellowish-white tissue which in some areas appeared to be degenerated and

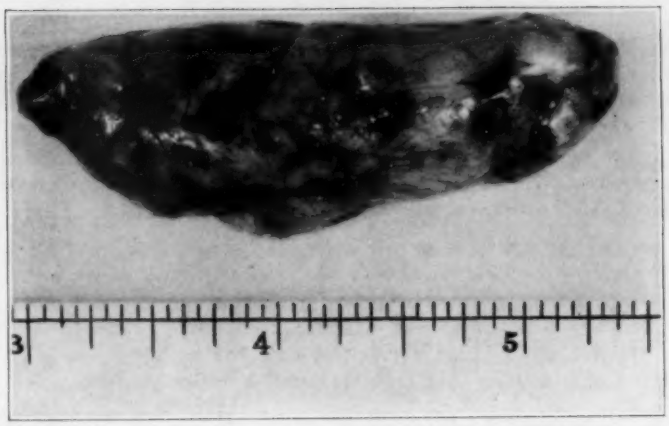

Fig. 4 (case 1).—An ependymal glioma after removal from the cervicothoracic portion of the spinal cord.

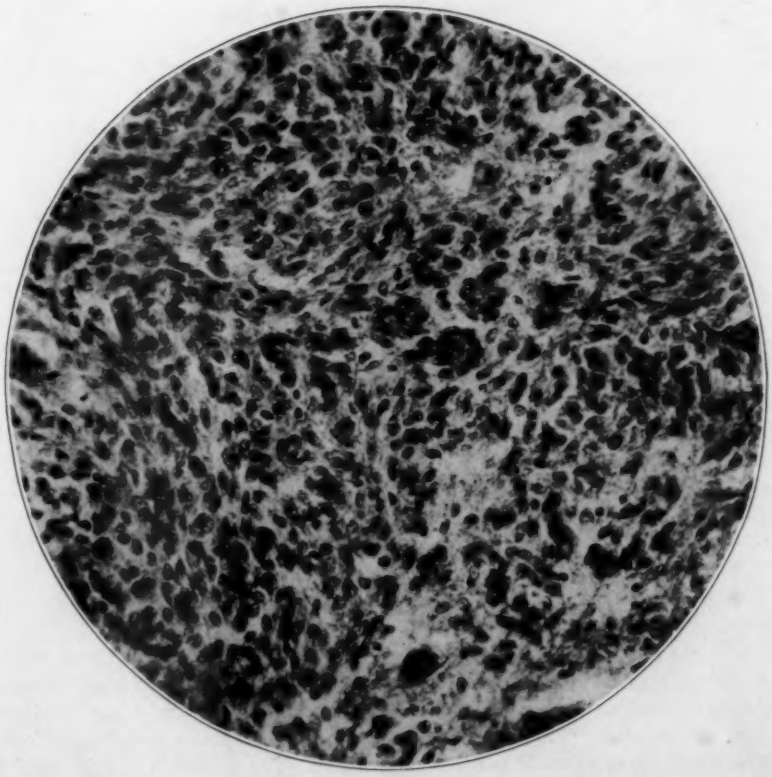

Fig. 5 (case 1).—A section of an ependymal glioma (ependymoblastoma) showing the markedly cellular character. Hematoxylin and eosin stain; × 220.

hemorrhagic. The fluctuant feel of the tumor was due to a degenerated central portion of the mass. This hemorrhagic degenerated portion extended throughout the entire tumor, and the lower pole revealed clots indicating recent hemorrhage. The histologic (fig. 5) examination revealed a rather cellular tumor with the cells tending to be grouped about clear spaces and blood vessels. In the midportion of the tumor was a definite epithelial lining of what was probably a central cyst. The diagnosis was ependymal glioma, probably of ependymoblastic type.

Comment.—This case is an example of one of the many diagnostic errors that may be made in attempting to identify the clinical picture of an intramedullary tumor of the spinal cord. For about six months this patient was thought possibly to have multiple sclerosis before it was recognized that a localized lesion of the cord was present. However, the result to date has been quite satisfactory, and at least our diagnostic wits have been sharpened by this experience.

CASE 2.—*Intramedullary ependymoma of the thoracic portion of the spinal cord. Complete removal of tumor at a second operation. Death due to meningitis.*

History.—B. E., a nurse 24 years old, was first admitted to the outpatient department of the Los Angeles County General Hospital on Feb. 1, 1932, with a complaint of pain in the back and weakness of both lower extremities. In 1927 she fell from a horse and since then had suffered severe backache in the lumbar region. Pain, which had been constant during the preceding three years, was aggravated by motion and was frequently associated with a sense of constriction about the waist. Until March 1930 the patient had been able to swim, dance and otherwise use all the extremities freely. About this time she noticed that her right ankle began to weaken and twisted easily; the right leg also gradually became weak and at times felt numb. During the nine months previous to admission to the hospital the left leg became similarly involved, and at the time of her first admission to the hospital both legs felt very numb and the patient was unable to locate the position of her feet without looking at them. Backache at this time was quite severe. The history otherwise was essentially irrelevant.

Examination.—Examination revealed a bright woman complaining of severe lumbar pain. The pupils, optic disks and cranial nerves were normal. There was weakness of both lower extremities with the legs about equally affected. On walking there was a slow, shuffling gait which did not seem to be particularly spastic. The biceps, triceps and radial reflexes were present and equal. The knee jerks were practically absent, and the achilles tendon jerks were present but very sluggish. There were no Babinski, Gordon and Oppenheim reflexes or ankle clonus.

There was a sensory level (fig. 6) at the ninth dorsal segment, below which all forms of sensation were markedly disturbed. Touch, pain and vibratory sensation were greatly diminished, and there was marked analgesia to pinprick. Sensation in the upper extremities was normal. Palpation over the spinous processes from the ninth to the twelfth dorsal vertebra produced pain and discomfort. There were no trophic disturbances.

Roentgen examination of the entire dorsolumbar portion of the spine revealed no material pathologic change.

Lumbar puncture revealed yellow cerebrospinal fluid under 100 mm. of pressure. There was no rise of pressure on jugular compression, revealing a complete subarachnoid block. Puncture of the cisterna magna revealed clear fluid under 80 mm. of pressure. The fluid withdrawn from the lumbar canal contained an increased amount of globulin and 10 lymphocytes. The urinalysis and blood picture were normal.

Diagnosis.—That the patient was suffering from a tumor of the spinal cord at about the level of the ninth dorsal segment was readily recognized, and with the marked amount of disturbance in the pain and temperature senses an intramedullary location was favored.

Operation.—On March 10, with the patient under ether anesthesia, a laminectomy was performed, removing the laminae of the seventh to the eleventh dorsal vertebra, inclusively. The dura appeared to be unusually tense, and on opening it the spinal cord immediately began to herniate; at the level of the eighth dorsal vertebra

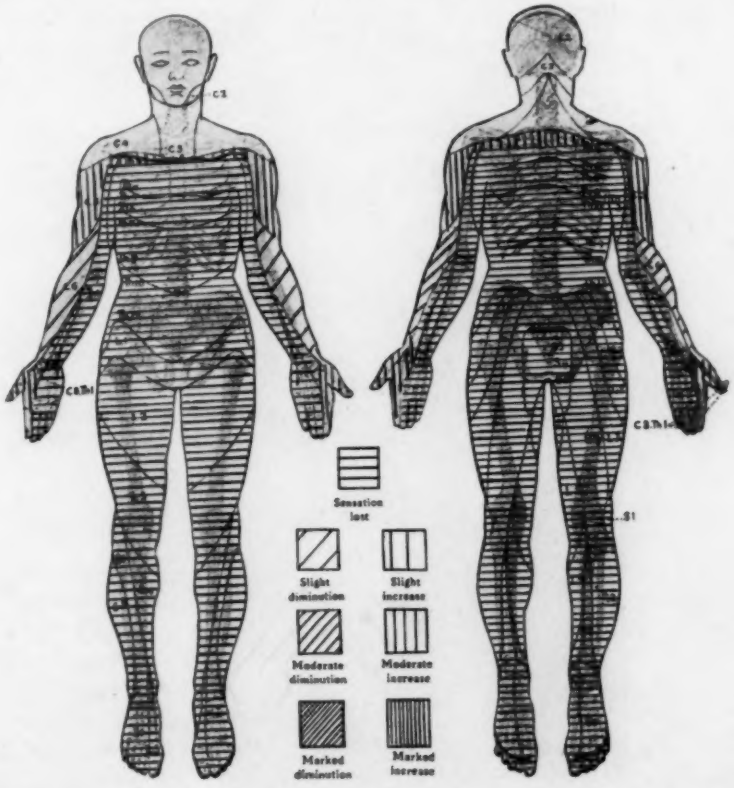

Fig. 6 (case 2).—A diagram showing the cutaneous sensory disturbances in a patient with an intramedullary tumor at the level of the ninth thoracic segment.

the cord appeared to be swollen and covered by enlarged tortuous vessels (fig. 7 *A*). A small hypodermic needle attached to a syringe was introduced into the cord in the midline in an attempt to aspirate fluid from a possible cystic cavity, but none was encountered. The cord generally appeared to be greatly widened and pulsated but feebly. It was thought best not to explore further and not to incise the cord. The dura was left open and the rest of the wound was closed carefully in layers.

Postoperatively the patient had a rather stormy convalescence; however, the wound healed well and the patient was discharged to her home on May 19. Before

leaving the hospital she was given several high voltage roentgen exposures, and at the time of leaving for her home she was able to walk about with the aid of a cane.

The patient did extremely well for almost a year and a half, during which time she used a cane for twelve months and then for almost six months was able to walk without support. She returned to the hospital on Oct. 10, 1933, with a complaint of severe pain in the back and legs. She stated that she had felt very well until one month previously. The neurologic findings at this time were practically the same as on the first admission. The sensory level was now limited by

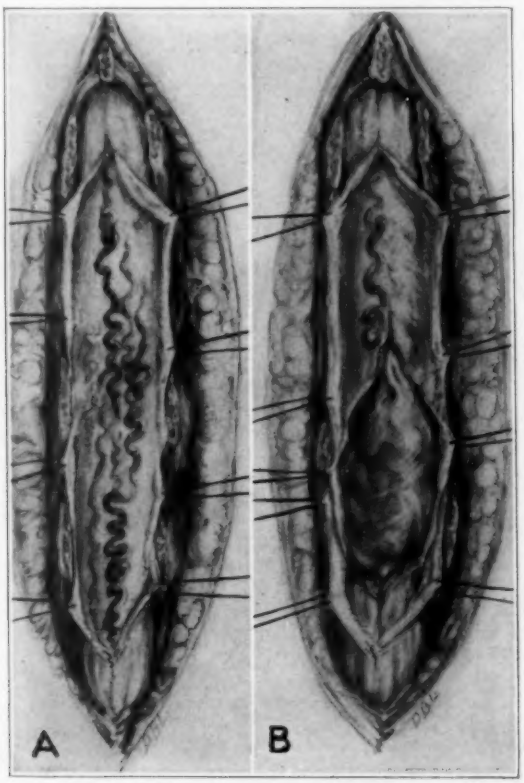

Fig. 7 (case 2).—*A* is a drawing showing the markedly swollen condition of the spinal cord with greatly enlarged vessels at the time of the first operation, and *B* is a drawing of the extrusion of an intramedullary tumor after midline incision of the spinal cord.

a zone of hyperesthesia from the sixth to the eighth dorsal segment, below which all forms of sensation were markedly diminished. The tendon reflexes in the lower extremities were very sluggish, and there were no pathologic reflexes. Examination of the spinal fluid revealed a markedly yellow fluid, and there appeared to be a complete subarachnoid block.

Pain in the legs and back became excruciating, and it was decided to reexplore the area previously examined in an effort to locate an intramedullary tumor. Our experience in the first case had furnished sufficient courage to make us feel that

incision of the cord might reveal a neoplasm amenable to surgical intervention. Accordingly, on October 26 an incision was made above the old operative scar beginning at the level of the fifth dorsal vertebra. The incision was carried down through the old operative wound in its entire length. At the level of the sixth dorsal vertebra the spinal cord appeared to be yellowish and swollen and felt cystic. A small incision was made in the midline of the spinal cord at the upper pole, and a small cyst was evacuated. At the lower end of this cyst at the level of the sixth dorsal vertebra a large grayish tumor presented itself. The overlying spinal cord was split in the midline to a depth of 1 mm., and the tumor gradually exposed. The neoplasm was gently elevated by means of silk traction sutures and was lifted from its bed from within the spinal cord (fig. 7 *B*). At the level of the tenth dorsal vertebra two large vessels were seen to be entering the tumor. These were caught with silver clips and divided. The laminae of the eleventh and twelfth dorsal vertebrae had to be removed before the tumor could be removed in its entirety. The wound was then carefully closed.

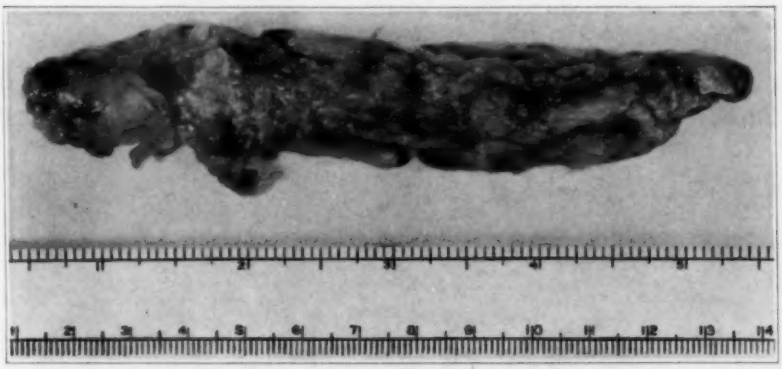

Fig. 8 (case 2).—An ependymal glioma from the thoracic portion of the spinal cord which extended from the sixth to the twelfth segment. It weighed 30 Gm. before fixation.

Course.—Postoperatively the patient had a very stormy course for several days and then appeared to be gradually improving. The lower extremities were markedly weak after the operation, with involvement of both sphincters. The sutures were removed on the tenth postoperative day. The temperature and pulse rate remained within normal limits throughout this period, but the patient complained continuously of severe pain in the back and vomited frequently. At this time the lower pole of the wound broke down and there developed a small cerebrospinal fluid fistula. Several attempts to repair the wound proved unsuccessful, and within a few days there developed the signs and symptoms of a meningeal infection with cervical rigidity and a high temperature. Supportive treatment proved to be of no benefit, and the patient died on December 11.

Pathologic Examination.—The tumor (fig. 8) measured 12.5 cm. in length and 2 cm. in diameter and weighed 30 Gm. shortly after removal and before fixation. It was somewhat cigar-shaped, being pointed at either end. It appeared to be encapsulated and presented numerous lobules of various size on its surface. The tissue was soft, reddish-gray, friable and mottled with hemorrhagic areas (fig. 9).

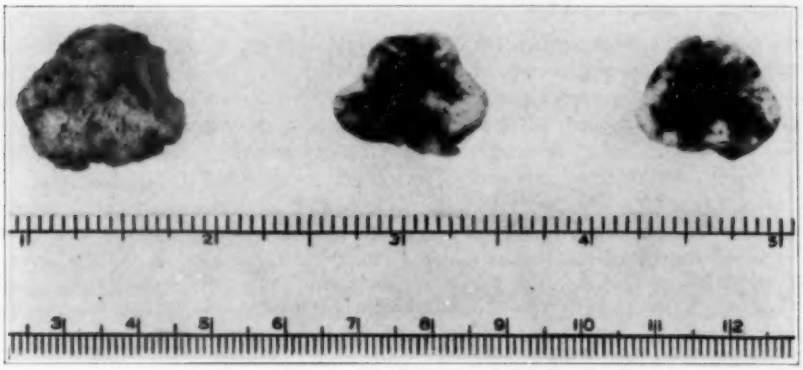

Fig. 9 (case 2).—Transverse sections of the tumor depicted in figure 8, showing marked vascularity.

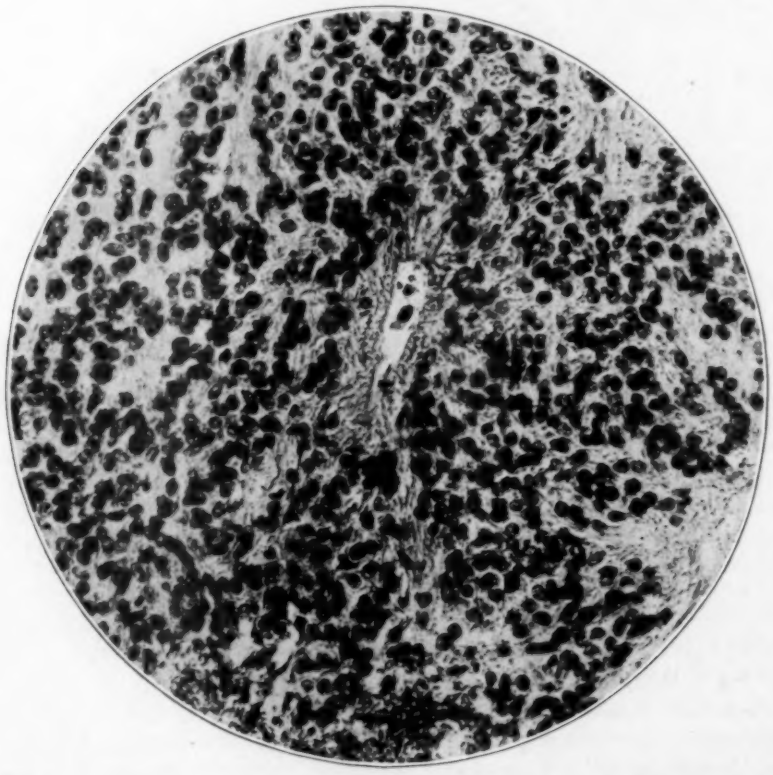

Fig. 10 (case 2).—A section of an ependymal glioma (ependymoblastoma), showing the tendency to form pseudorosettes about the blood vessels. Hematoxylin and eosin stain; × 220.

Histologic Examination.—Examination revealed an ependymal glioma (fig. 10). The major portion of the tumor had a rather characteristic appearance with the cells tending to be arranged in pseudorosettes about a central blood vessel. However, some of the numerous larger cavities were lined with a condensed form of tissue representing embryonic ependyma. The tumor resembled that type of ependymal glioma known as an ependymoblastoma.

Comment.—Although the result in case 2 might well be termed a surgical disaster there are a few features concerned with the differential diagnosis as well as with the surgical technic that warrant careful study.

It is often extremely difficult to differentiate clearly between intramedullary and extramedullary tumors of the spinal cord. The absence of irritation of the posterior roots, a dissociated waistcoat type of sensory disturbance and a marked difference in the levels of the various sensory disturbances suggest intramedullary new growth. The presence of pain is not a commonly known symptom of intramedullary tumors, and its presence in case 2 was rather disconcerting. It has been explained as being due to associated adhesions of the arachnoid (arachnitis) by Foerster [32] in several of his cases of intramedullary tumor, and it is possible that pain in the roots can be produced by a tumor arising near the posterior horns. The duration of symptoms before surgical relief is sought can no longer be held as a criterion of intramedullary neoplasms. Kernohan [4] had three patients with intramedullary ependymomas, with histories of ten, thirteen and fourteen years' standing, respectively. As Spiller [33] said: "It is somewhat remarkable to think that the intramedullary group of tumors may have a longer duration of symptoms than the extramedullary and extradural tumors, particularly when one considers the small diameter of the spinal cord and the slight injury which is required to lead to complete paralysis." But with his usual sagacity Spiller suggested that "if the tissues studied were to be stained with the Bielschowsky silver stain, one might find that in many of these tumors axis cylinders passing directly through the tumor without being destroyed and therefore capable of functioning although under difficulty."

It is particularly important that scrupulous care be paid to effecting a tight closure of the wound so as to avoid a cerebrospinal fluid fistula, with a subsequent fatal infection. This complication is prone to develop in cases of this type when the dura is purposely left open and, as in case 2, may be the direct cause of a fatal issue. In one of the cases reported by Cairns and Riddoch [31] such a complication developed following operation but the patient finally recovered from the meningeal infection.

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32. Foerster, O.: Die Leitungsbahnen des Schmerzgefühls und die chirurgische Behandlung der Schmerzzustände, Berlin, Urban & Schwarzenberg, 1927.

33. Spiller, W. G., in discussion on Kernohan, Woltman and Adson.[4]

SUMMARY AND CONCLUSIONS

The ependymal glioma has come to be recognized as the common parenchymatous tumor of the spinal cord.

The surgical amenability of this type has not been sufficiently recognized when a large swollen spinal cord is exposed at operation and an intramedullary tumor is thought to be present.

This type of glioma tends to be encapsulated, offering a fair prognosis if successfully removed.

Surgical intervention employed in the treatment of such an intramedullary tumor includes, according to a consensus: (1) a wide laminectomy; (2) incision along the middorsal aspect of the cord with separation of the posterior columns; (3) removal of the tumor by careful blunt dissection with the aid of silk traction sutures; (4) leaving the dura open to provide sufficient decompression, and (5) careful tight closure of the wound.

Roentgen therapy following operation does not seem to be indicated, since this type of tumor appears to be benign.

Two cases of intramedullary spinal cord tumor of ependymal origin that have come to operation are described in detail.

USE OF LOW TEMPERATURES IN CULTURE AND TRANSPORTATION OF SURGICAL MAGGOTS

S. W. SIMMONS, B.Sc., M.A.
WASHINGTON, D. C.

Efficient retardation of development in the culture of surgical maggots permits the technician to maintain a constant supply with minimum effort. It is also one of the chief means by which cost of production can be lowered. Retardation is essential during the period of incubation in the tests of sterility, and it would be both economical and convenient if development could be restrained beyond this period. As subjection to low temperature has been the chief means of retardation, an investigation was made to determine its effect on maggots in storage.

A common practice of surgeons requiring a small or occasional supply of maggots is to purchase them from certain medical supply houses, and frequently shipments have to be made over long distances. Normally maggots develop rapidly, and if allowed to grow in transit they become too large for use in the wound. Their development has to be retarded in some way, therefore, during shipment. The usual method of preparing maggots for shipment is to pack the container next to ice in an insulated package. The package, however, is heavy and bulky and is expensive to prepare and mail. The greatest objection raised by surgeons using maggots for treatment has been the expense, many of their patients being dependent on charity. With a view to the reduction of expense, therefore, an investigation was also made of the efficiency of retardation by low temperature in transit.

Maggots used in this work were of the species Lucilia sericata; they were reared under the usual aseptic technic.[1]

PROPORTION OF MAGGOTS THAT FEED AT VARIOUS TEMPERATURES

Both in storage and in transit, restraint of growth is of primary importance. Tests were therefore conducted to determine the proportion

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From the Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

1. Robinson, W.: Improved Methods in the Culture of Sterile Maggots for Surgical Use, J. Lab. & Clin. Med. **20**:77 (Oct.) 1934. Simmons, S. W.: Sterilization of Blowfly Eggs in the Culture of Surgical Maggots for Use in the Treatment of Pyogenic Infections, Am. J. Surg. **25**:140, 1934.

of maggots that feed under various temperatures which might be chosen for the production of retardation.

Maggots of surgical size (from 4 to 6 mm. long) were removed from their food and subjected to the temperatures shown in table 1. They were then placed on colored food of the same temperature and returned to the refrigerator. Thus no feeding occurred except under controlled conditions. After approximately twenty-four hours all living specimens were examined microscopically for the presence of food in the alimentary tract.

The colored food was prepared by making a solution of normal beef blood serum and adding enough safranine to produce a deep red. After being mixed, the food was coagulated by heating and placed in the food bottles for autoclaving. Even slight feeding was detected in the intestinal tract, and tests proved that maggots fed readily on this food.

Observations indicated that there was feeding as long as activity persisted. Little feeding occurred at 4 C. (39.2 F.); however, while at from 8 to 9 C. (46.4 to 48.2 F.) 53.2 per cent of the maggots fed (table 1). When the temperature was increased to 10 or 11 C. (50 or 51.8 F.), the proportion was increased to 80.6 per cent. Almost all the maggots (98.5 per cent) fed when a temperature of 20 C. (68 F.) was reached. The quantity of food consumed increased, of course, with the temperature.

TABLE 1.—*Relation of Temperature to the Number of Maggots that Feed*

Temperature, Degrees		Number of Maggots Used	Maggots That Fed	
C.	F.		Number	Per Cent
4 - 6	39.2 - 42.8	381	17	4.4
8 - 9	46.4 - 48.2	62	33	53.2
10 - 11	50 - 51.8	268	216	80.6
20 - 21	68 - 69.8	198	195	98.5
27 - 29	80.6 - 84.2	109	107	98.2

GROWTH OF MAGGOTS AT VARIOUS TEMPERATURES

In tests already mentioned, 53.2 per cent of the maggots fed at a temperature of from 8 to 9 C. (46.4 to 48.2 F.). The amount of feeding, however, was negligible. The actual amount of growth, therefore, and not merely the indication of feeding, is the criterion to be used in establishing a temperature suitable for retardation. Tests were conducted to determine this temperature.

Maggots were taken from their food (composed of dehydrated liver, agar, yeast and water) and washed with distilled water for one minute to remove particles of food. The surface water was removed by allowing the maggots to crawl over filter-paper for four minutes. They were then counted, weighed and placed in the refrigerator until chilled to storage temperature. After this they were placed on fresh food of the same temperature, returned to the refrigerator and allowed to feed for seventy-two hours. This period was chosen because it is that for which

the cultures used in the sterility tests are incubated before the maggots are released and because it represents about the average time required for maggots in transit. Growth during storage was determined by removing the specimens and washing and weighing them as before. Four tests with 100 maggots each were made for each range of temperature indicated in table 2.

At a temperature of from 10 to 11 C. (50 to 51.8 F.) the increase in growth, namely, 23.4 per cent of the prestorage weight, can be tolerated without materially shortening the period of feeding of the maggots after implantation in wounds. A temperature of from 13 to 14 C. (55.4 to 57.2 F.) caused an increase of 90.7 per cent in weight. A higher temperature is, therefore, unsatisfactory, as maggots showing an increase in weight beyond 23.4 per cent would be excessively large after storage and would have only a short period of feeding in the wound.

On the basis of these tests, a maximum effective temperature was fixed at 12 C. (53.6 F.) as the highest temperature that can be tolerated in the retardation of maggots.

TABLE 2.—*Relation of Temperature to Growth of Surgical Maggots During Seventy-Two Hours*

Temperature, Degrees		Mean Prestorage Weight per Specimen, Mg.	Mean Poststorage Weight per Specimen, Mg.	Mean Gain in Weight per Specimen During Storage, Mg.
C.	F.			
10 - 11	50 - 51.8	4.7	5.8	1.1
13 - 14	55.4 - 57.2	4.3	8.2	3.9
15 - 16	59 - 60.8	4.1	16.9	12.8
20 - 21	68 - 69.8	6.5	22.4	15.9

EFFECT OF RETARDATION BY LOW TEMPERATURE ON VIABILITY OF MAGGOTS

The mortality of maggots during storage is of much importance. Although low temperature is used extensively as an agent to induce retardation it also causes a high mortality. If a high death rate during retardation could be avoided, maggots could be held in an arrested state for several days. This would considerably reduce the expense of production and, by permitting long distance shipments, would make surgical maggots more available to remote districts. Tests were conducted to determine whether the death rate is so great as to make the continued use of this method of retardation inadvisable.

The maggots used in these tests were reared on the nutrient food already mentioned, under the usual aseptic precautions; when they reached surgical size they were stored in the same kind of food at a temperature of from 5 to 6 C. (41 to 42.8 F.) for periods ranging from one to six days.

The period of mortality may be divided into two phases: (1) the time from the hatching of the eggs until the maggots are implanted in the wound and (2) the period after implantation. Maggots that survive cold storage are not necessarily able to resume feeding when placed in the wound, and obviously they would be

of no clinical value if unable to feed. As a test of the tolerance of maggots to cold storage, it was therefore required that they should be able to feed and grow when placed on necrotic tissue.

Cold storage of surgical maggots caused an extreme mortality (table 3). After two days' storage, which is the usual period of retardation during the sterility tests, the mortality was 66.6 per cent. The fact that two thirds of the maggots were lost during this period of storage is significant, and as the death rate increased rapidly each day, the futility of prolonged storage is evident. When maggots were retarded for six days the mortality was almost 100 per cent, while maggots reared under similar conditions but not subjected to cold had a mortality of only about 19 per cent.

TABLE 3.—*Mortality of Surgical Maggots Resulting from Cold Storage at from 5 to 6 C. (41 to 42.8 F.)*

Time in Storage, Days	Number of Experiments Conducted	Number of Maggots Used	Number That Survived Storage	Number Able to Resume Feeding	Percentage of Mortality*
1	7	3,006	2,655	1,104	63.3
2	6	2,764	1,650	922	66.6
3	6	2,823	1,112	604	78.6
4	5	2,183	781	397	81.8
5	4	985	391	119	87.9
6	2	448	55	7	98.4

* The number includes those that were dead when removed from storage and those not able to resume feeding.

The enormous death rate of surgical maggots caused by cold storage often escapes detection, and the fact that about one half of those which do survive storage are unable to resume feeding is still more likely to be overlooked. Fortunately, another method of retardation is possible [2] which eliminates the use of low temperature. This method considerably reduces the expense and labor involved in the culture of maggots and, by lowering the mortality of the maggots, increases their therapeutic value.

RETARDATION OF MAGGOTS IN TRANSIT BY LOW TEMPERATURE

When maggots are purchased shipment by mail is usually necessary and the essential retardation during transit has been attempted chiefly by packing in iced containers.

Method.—To test the efficiency of this method, determinations were made of the temperatures within the packages, and these temperatures were compared with the maximum effective temperature of 12 C. (53.6 F.). Two standard types of packages were prepared for shipment in the usual way. One type was a cylindric

2. Simmons, S. W.: Adequacy of Nutritional Retardation in the Culture of Sterile Maggots for Surgical Use, this issue, p. 1024.

carton having metal ends and insulated with corrugated paper and cellulose. Some of these cartons were placed on end and others on their sides, as in transit. The second type was a rectangular cardboard box filled with ground cork for insulation. Ice was supplied in the usual way, by freezing water in tin cans of a capacity of 245 cc. Each bottle of maggots, with the usual small quantity of nutrient food, was packed next to the can of ice.

The temperature of each bottle after packing was determined with a four point multiple thermocouple placed in the bottle in the following position: Point 1, in contact with the base of the cotton plug; point 2, suspended in mid-air between the base of the bottle and the plug; point 3, fastened to the inner wall of the bottle on the same level as point 2, and point 4, inserted into the food.

Readings were taken at one-half hour or one hour intervals, and tests were conducted under the shipping conditions of both summer and winter.

Tests Under Summer Conditions.—The tests were made in July with atmospheric temperatures (chart 1) of from 30 to 33 C. (86 to 91.4 F.). The only

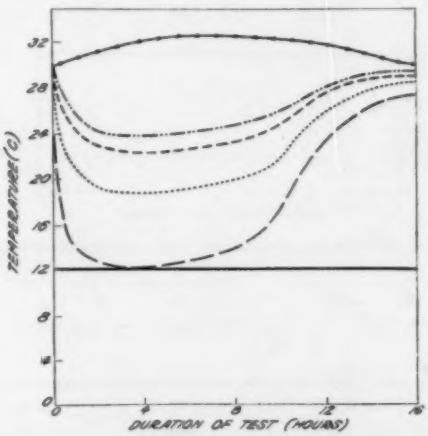

Chart 1.—Temperatures in cylindric iced shipping package under summer conditions. In this chart and in the accompanying charts, the solid straight line represents the maximum effective retardation-inducing temperature; the solid curved line with crosses, the temperature of the air; the line of dash and dots, the temperature of point 1; the line of short dashes, the temperature of point 2; the line of medium dashes, the temperature of point 3, and the line of long dashes, the temperature of point 4.

temperature in the cylindric iced package low enough to produce successful retardation was recorded by point 4, which was inserted in the food next to the ice. This temperature was 12.1 C. (53.8 F.), but it lasted only about one hour. The temperatures in the upright and prone packages were similar, and their averages were taken. About the cotton plugs it was always warmest, the mean minimum temperature being 24 C. (75.2 F.). In sixteen hours the mean minimum temperature was 27.5 C. (81.5 F.), at which temperature maggots are always active and feeding. Thus it is evident that under summer conditions practically no retardation of the maggots is accomplished by this method.

The temperatures in the rectangular package were more uniform (chart 2) but higher. The food was always warmest and the wall of the jar coolest, but the

difference in temperature was only about 3 C. (5.4 F.). The mean minimum temperature was 18.5 C. (65.3 F.), which was not sufficiently low to produce dormancy of the maggots.

These tests were purposely conducted under the most unfavorable atmospheric conditions of summer, so that the adequacy of retardation by low temperature for the conditions of this season and of tropical countries might be determined.

Tests Under Winter Conditions.—Winter temperature was obtained by placing the package in a mechanical refrigerator maintained at 20 C. (68 F.). This tem-

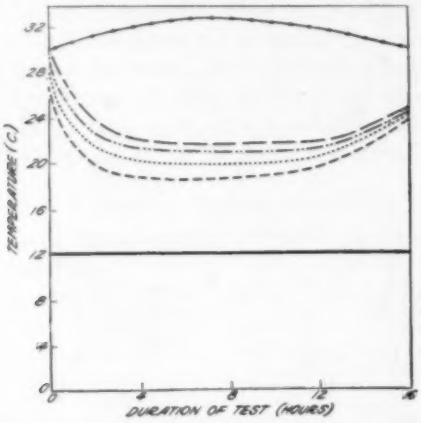

Chart 2.—Temperatures in rectangular iced shipping package under summer conditions.

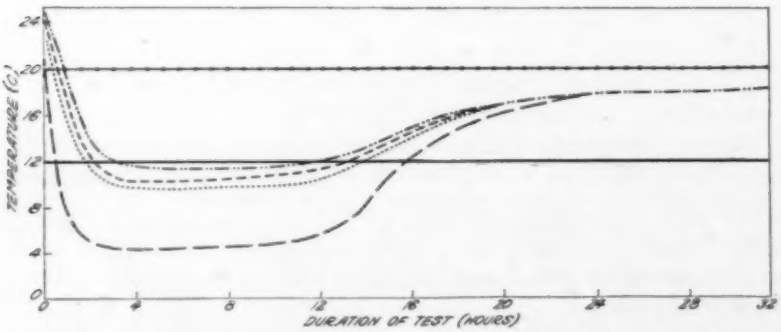

Chart 3.—Temperatures in cylindric iced shipping package under winter conditions.

perature was chosen as that usually encountered by maggots in mail-coaches and post-offices. The insulation of the bottle prevents chilling when the package is exposed for brief periods outside.

Under these conditions the temperatures in the bottles were both lowered and prolonged. In the cylindric containers the temperatures bore a parallel relationship to those under summer conditions. The lowest temperature, 4.5 C. (40.1 F.), was reached in the food (chart 3). By the first hour this had risen to 7.5 C. (45.5 F.); no appreciable increase occurred before the end of fourteen hours. A uniform temperature of 17.5 C. (63.5 F.) was recorded throughout the bottle in twenty-three

hours, and it was approximately that of the surrounding atmosphere in thirty hours. All portions of the bottle were sufficiently cooled to produce a successful degree of dormancy, but only for fifteen hours. The duration of the retardation-inducing temperature in the warmest portion of the bottle was only about eight hours, and, as is shown later in this paper, it is naturally this portion in which the maggots tend to cluster.

In the rectangular package the temperatures of the bottle were lower and rose more slowly, of course, than under summer conditions. The variation in temperature between the different parts of the bottle (chart 4) was only 2.5 C. (4.5 F.), and all temperatures had the same relationship to each other as those under summer conditions. In this type of package the temperatures also fell and rose more slowly than in the cylindric container. The lowest temperature was recorded on the side adjacent to the ice. There an effective retardation-inducing temperature was maintained for eighteen hours, while in the food the time of retardation was reduced to fourteen hours. A successful degree of retardation of the maggots was obtained in all portions of the bottle, but the low temperature did not persist long enough to permit successful long distance shipping.

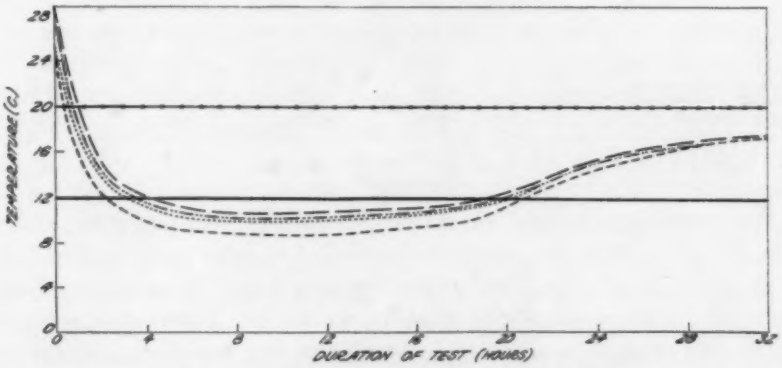

Chart 4.—Temperatures in rectangular iced shipping package under winter conditions.

EFFECT OF TEMPERATURE GRADIENT ON MIGRATION OF MAGGOTS

As the temperatures in a bottle of maggots varied when placed next to ice, it was assumed that the specimens would migrate to the warmest part. The lower temperatures would thus be ineffective. Tests were therefore conducted to determine this point.

Bottles containing food and maggots were placed on cans of ice, and the activity of the maggots was observed as the temperature fell.

In each case the maggots began to wander from the food when it was chilled to 18 C. (64.4 F.). They fed readily, however, at this temperature if no higher one was available. Further chilling to 14 C. (57.2 F.) caused most of them to leave the food and cluster in the warmer parts near the plug, and they returned to the food only when it had become warm. In charts 1, 2, 3 and 4, it is shown that this migration considerably reduced the effectiveness of the retardation-inducing temperature during shipment. On the basis of this migration, retardation lasted only about fourteen hours under the most favorable conditions (chart 4).

The foods so far in use, unfortunately, tend to run to the warmer parts of the bottle, thus becoming available to the maggots and promoting rapid growth during most of the period in transit. The tendency, therefore, is toward either overgrowth or excessive mortality, either of which prevents satisfactory utilization of this method.

TEMPERATURE AT WHICH MAGGOTS FREEZE

Tests to determine the temperatures at which the maggots would freeze were made with a thermocouple by the contact method, as devised by Robinson.[3] The specimens used were of the typical surgical size (from 4 to 6 mm. in length). A summary of the data is given in table 4.

As freezing cannot occur until the undercooling point is reached, it is seen that freezing is impossible under ordinary conditions of cold storage.

TABLE 4.—*Undercooling and Freezing Points of Surgical Maggots*

	Undercooling Points, Degrees		Freezing Points, Degrees	
	C.	F.	C.	F.
Maximum temperature	—14.6	7.9	—7.2	19.8
Minimum temperature	—10.0	14.0	—4.1	25.0
Average temperature	—11.4	12.9	—5.5	23.9

COMMENT

The customary method of retardation of surgical maggots by low temperature is inefficient. After two days of storage at from 5 to 6 C. (41 to 42.8 F.) only one third of the maggots were able to resume feeding under conditions similar to those in the wound; a period of retardation of this length is necessary during the sterility tests. After an additional storage of four days, as would be required during shipment or when surplus maggots were held on hand, less than 2 per cent fed.

The use of iced containers for maggots in transit is not only expensive but inefficient. In summer no significant degree of retardation is obtained by ice alone. In winter a certain degree of retardation is possible. This may last as long as from eight to eighteen hours but this time is not sufficient to permit successful shipping for long distances.

At temperatures between 15 and 21 C. (59 and 69.8 F.) maggots gained about 75 per cent in weight during seventy-two hours. This range of temperature is always available to them under shipping conditions in summer and during most of the time under conditions in winter.

Since the completion of this investigation, one medical supply house has used a larger ice can (with a capacity of 445 cc.), which somewhat prolongs the duration of the retardation-inducing temperature. However, if the period were to be increased three times, there would be only

3. Robinson, W.: Determination of the Natural Undercooling and Freezing Points in Insects, J. Agric. Research **37**:749, 1928.

about two days of retardation under the most favorable conditions, and, as already shown, only one third of the maggots would be able to resume feeding. The increased quantity of ice also adds considerably to the weight of the package and the cost of mailing.

In the cases in which packing with ice has been employed with apparent success, the results have been largely due to the fact that the maggots' food was sufficiently low in nutrient value to aid greatly in the retardation.

In view of the inadequacy of retardation by low temperature a more satisfactory method is desirable. In an accompanying paper [2] a method of effecting retardation by nutritional means alone is described. With this new method the disadvantages are less than with cold storage and the period of successful retardation is considerably longer.

SUMMARY

A study was made of the value of retardation of surgical maggots by low temperature. The work included an investigation of the proportion of maggots that feed at various temperatures, showing that over 75 per cent of the maggots fed at 10 C. (50 F.).

The size of the maggots increased 23.4 per cent when they were stored for seventy-two hours at from 10 to 11 C. (50 to 51.8 F.), while at from 13 to 14 C. (55.4 to 57.2 F.) the increase was 90.7 per cent. Any temperature higher than 12 C. (53.6 F.) was found to stimulate too rapid growth and development for successful retardation of the maggots.

The mortality of maggots in storage at low temperatures is extremely high. Even when stored for forty-eight hours at from 5 to 6 C. (41 to 42.8 F.), only one third were able to resume feeding, and the mortality was nearly 100 per cent after six days. This high rate necessitates the early use of the maggots and prohibits their retention for later use when not needed immediately.

As this method of retardation is used in shipping maggots by mail, its efficiency has been investigated from that standpoint. Tests were conducted under conditions of both summer and winter and it was found that the temperature was not sufficiently low over a long enough period to prevent growth and development during transit.

The temperature in a bottle of maggots packed next to ice is not uniform throughout, and maggots migrate to the warmer portions. The retarding effect of the lower temperature is therefore lost.

If a sufficiently low temperature could be maintained throughout the period of transit, most of the maggots would be killed, as they are not tolerant of such conditions.

Reference is made to an investigation in which a method has been devised for the nutritional retardation of maggots.

ADEQUACY OF NUTRITIONAL RETARDATION IN CULTURE OF STERILE MAGGOTS FOR SURGICAL USE

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Retardation is a necessity and a convenience in the production of maggots for surgical use. It is an essential step in the process because during the tests of sterility, which are made on all maggots, the growth of the maggots must be restrained; otherwise they become too large for use in wounds. It is also essential during long distance shipments. Retardation is a convenience, as it permits the holding over of maggots not needed at the time.

Low temperature is at present the chief means used to produce retardation, but a recent investigation [1] has shown this method to be injurious, chiefly because it destroys a large percentage of the maggots. In view of the need of a more efficient method, experiments were conducted on retardation by nutritional means.

The maggots used were those of the species Lucilia sericata; they were reared under the usual aseptic technic.[2] All cultures were kept in a cabinet maintained at 27 C. (80.6 F.).

THE RETARDATION-INDUCING FOOD

Standards of a Retardation-Inducing Food.—There are various foods by which the growth of maggots can be retarded, but most of these cause considerable mortality or lack some of the essentials to be enumerated.

A good food for this purpose should conform to the following standards: (1) The food must permit only a slow rate of growth; (2) it must at the same time retard development in conformity with the slow rate of growth; (3) the mortality during retardation should be slight; (4) the food should be nutritionally homogeneous throughout to allow uniform growth of all the maggots; (5) it should be of the proper consistency to permit free activity of the maggots; (6) it should permit the easy removal of the maggots; (7) it should resist drying; (8) the

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From the Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

1. Simmons, S. W.: Sterilization of Blowfly Eggs in the Culture of Surgical Maggots for Use in the Treatment of Pyogenic Infections, Am. J. Surg. **25**:140, 1934.

2. Robinson, W.: Improved Methods in the Culture of Sterile Maggots for Surgical Use, J. Lab. & Clin. Med. **20**:77, 1934. Simmons.[1]

food materials should be accessible to the laboratory; (9) the food should be simple, cheap and easy to prepare.

Preparation.—A wide range of foods was tested. The one which proved to be the best and simplest is prepared as follows: evaporated milk (fresh), 1 part;[3] distilled water, 7 parts; agar, 1.5 per cent.

The milk and water are mixed; the agar is then added, and the mixture is cooked in a double boiler for about twenty-five minutes. It should be poured into the food bottles[4] while hot. Ordinarily, from 12 to 15 cc. is used in each bottle. The proportion of milk and water is sufficiently nutritious to sustain the larvae without allowing material growth and development. Some latitude in concentration is tolerated, however, any ratio of from 5 to 7 parts of water to 1 part of milk being suitable. Solutions of less than 1 part of milk to 7 parts of water are not satisfactory, as the milk tends to settle out during autoclaving so that it is overlaid with clear agar. This condition is not desirable, as newly hatched larvae should have immediate access to the milk.

A 1.5 per cent solution of agar gives a jelly-like consistency which is sufficiently soft to allow free activity of the maggots and yet is firm enough to prevent running. The agar acts as a hydrophilic colloid and thus prevents undue desiccation of the food. This action is important, as lack of moisture is detrimental to the maggots. The specimens are easily removed from the food by pouring sterile water into the bottle and stirring with an applicator, after which the maggots are strained out. If cold water is used the maggots are subdued so that they will not escape from the wound before the cage is applied.

GROWTH AND DEVELOPMENT OF SURGICAL MAGGOTS ON RETARDATION-INDUCING FOOD

The rate of development as well as of growth must be reduced by the retarding agent. Although the two functions usually occur simultaneously, they can be separated. If growth alone were arrested and development continued, the maggots would be useless surgically after about five days, even though they were no larger than normal surgical maggots, for they would not feed in the wound. On the other hand, if growth were well advanced before implantation, one of the outstanding activities of the maggots, namely, the removal of necrotic tissue in feeding,[5] would be correspondingly reduced.

In the evaluation of the food it was therefore necessary to determine the rate of growth and development of maggots during various periods of retardation. This was done by making measurements of size and

3. The proportion used was based on the usual commercial concentration, which is about twice that of whole milk.

4. Robinson, W., and Simmons, S. W.: Surgical Maggots in the Treatment of Infected Wounds: Recent Apparatus and Methods in Maggot Production and Research, J. Lab. & Clin. Med. **19**:339, 1934.

5. Robinson, W., and Norwood, V. H.: The Rôle of Surgical Maggots in the Disinfection of Osteomyelitis and Other Infected Wounds, J. Bone & Joint Surg. **15**:409, 1933.

determinations of instar every twenty-four hours until the period of successful retardation had passed.

It was found that limitation of both growth and development could be effected (table 1) without allowing the maggots to grow beyond the recommended surgical size of from 4 to 6 mm. in length. On the eighth day the average length of the maggots was only 6.3 mm. Then followed a period of slight shrinkage. While a small percentage of the maggots developed into the third instar after one week, the majority remained in the second instar throughout the period of retardation. As feeding takes place chiefly in the third instar, it is evident that the maggots would have four or five days for feeding after implantation.

These tests were conducted with the usual number (from 500 to 700) of sterile maggots in each bottle. When an extremely small number is used, however, growth tends to be more rapid.

TABLE 1.—*Growth and Development of Maggots on Retardation-Inducing Food*

Age of Maggots from Sterilization of Eggs, Days	Length, Mm.	Percentage of Maggots in Each Instar		
		First	Second	Third
1	2.0	100	..	..
2	2.8	60	40	..
3	4.3	..	100	..
4	5.3	..	96	4
5	5.6	..	96	4
6	6.0	..	88	12
7	6.0	..	76	24
8	6.3	..	70	30
9	6.2	..	72	28*
10	6.0	..	64	36

* On the ninth day slightly fewer maggots appeared in the third instar than on the eighth day. This may be attributed to the incidental results of the random sampling.

MORTALITY DURING RETARDATION

Two periods of mortality may be considered as a result of retardation: (1) the time from the hatching of the eggs to the implantation in the wound, during which the maggots have the retardation-inducing food and (2) the interval after transference to the wound. The second period will be discussed in the following section.

In determining the mortality during the first period, a series of bottles of sterile specimens was prepared, each bottle containnig equal numbers of eggs by weight.[4] On the third day of retardation the maggots from one third of these bottles were counted; the others were counted on the sixth and ninth days, respectively. The average mortality for each series is shown in a succeeding paragraph, but a certain degree of fluctuation occurred within the series.

The total number of live specimens from the three day series was 861; no dead maggots were seen. With retardation by low temperature for three days, however, there was a mortality of 60 per cent.[6] On the sixth day the total number

6. Simmons, S. W.: Use of Low Temperatures in the Culture and Transportation of Surgical Maggots, this issue, p. 1014.

of live maggots was 762, showing a mortality of 11.5 per cent due to nutritional retardation as compared with that of 87 per cent due to retardation by low temperatures. The total number of maggots in the nine day series was 727, which is a decrease of 15.6 per cent from that in the three day series. With retardation by low temperature all the maggots were killed in nine days.

EFFECT OF NUTRITIONAL RETARDATION ON FEEDING IN THE WOUND

As retardation is an unnatural process, unfavorable effects which might manifest themselves after implantation of the maggots in the wound were to be considered. If maggots were to die prematurely in the wound or fail to feed vigorously, their therapeutic value would, of course, be correspondingly reduced. It was therefore essential to determine (1) the proportion of maggots that would resume feeding when transferred to the necrotic tissue, (2) the amount of tissue consumed and (3) the length of time the maggots would feed. These points are discussed in the following subsections.

The laboratory tests described in this section were supplemented by clinical observations made on patients at the George Washington University Hospital, the Gallinger Municipal Hospital and the Emergency Hospital, in which nutritionally retarded maggots were supplied for the purpose. The results were confirmed in numerous instances by surgeons in various parts of the United States.

Technic.—Twenty-seven bottles of sterile maggots were prepared, and as a check the tests were conducted in two series. After the maggots were 3 days old, a known number of several hundred from each of a number of bottles was transferred to a definite quantity of necrotic beef. This procedure was repeated with maggots 5, 6, 7, 8 and 9 days old. The containers of meat were placed on sand, which was examined each day for maggots. The meat was also examined for dead maggots. Any maggots left in the meat after five days of feeding were removed and counted. By this method the proportion able to resume feeding and the length of the period of feeding were determined.

In each series additional containers of meat, without maggots, were prepared as controls to determine the natural loss of weight by desiccation. The average weight of meat per container was 144.2 Gm., and the maximum variation between individual containers did not exceed 1.4 Gm. This was true of the containers both with and without maggots. The loss in weight averaged about 37 per cent, and, with this factor known, the quantity of tissue consumed by the larvae could be determined. It is probable that the amount of desiccation from the two groups of food differed slightly, owing to the activity of the maggots in the one group. This variation, however, should have little practical bearing on the results obtained.

Proportion of Maggots Able to Resume Feeding.—Practically no injury to the larvae was evident after three days of nutritional retardation. This is shown by the fact that 79.6 per cent of the maggots that hatched developed to maturity when placed on necrotic tissue (table 2).

This proportion is as great as the number which ordinarily mature when reared on nutrient cultural food. When retarded by a low temperature of from 5 to 6 C. (41 to 42.8 F.) for three days, however, only 21.4 per cent were able to resume feeding.[6]

There was little additional mortality after five days of retardation, as 76.6 per cent of the maggots developed to maturity when placed on necrotic tissue. This number is in striking contrast to that of maggots retarded for the same length of time by low temperature, of which only 12.1 per cent were able to resume feeding. After six days this number was reduced to 1.5 per cent,[6] while with nutritional retardation 70 per cent of the maggots were able to continue feeding.

After seven days of retardation a considerable drop occurred in the percentage of maggots which were able to feed. On the basis of the

TABLE 2.—*Effects of Nutritional Retardation and Retardation by Low Temperature on the Number of Maggots Able to Resume Feeding and on the Amount of Tissue Removed* *

	Percentage of Maggots Able to Feed		Necrotic Tissue Consumed per Hundred Maggots, Gm.	
Retardation Period, Days	Nutritional Retardation	Retardation by Low Temperature	Nutritional Retardation	Retardation by Low Temperature
3	79.6	21.4	6.4	1.8
5	76.6	12.1	6.0	1.0
6	70.0	1.5	5.1	0.1
7	51.8	0.0	4.8	No observation
8	45.3	0.0	3.8	No observation
9	28.1	0.0	2.1	No observation

* The results are based on a definite number of maggots at hatching.

number that hatched, 51.8 per cent were able to feed and develop to maturity, while after eight days the number was reduced to 45.3 per cent. This proportion is twice as great, however, as the number which were able to feed when retarded for only three days by low temperature. It is not possible to keep maggots under low temperature in a condition in which they will feed after seven days.

At the end of nine days 28.1 per cent developed to maturity when given the proper food. The mortality incurred after this time is often compensated for by the convenience of holding over sterile maggots for future use.

The usual mortality in a bottle of maggots is extremely difficult to detect and therefore frequently overlooked. Because dead maggots are sometimes moved about or obscured from view by the activity of living ones, the assumption is often made that they are all alive. On making actual counts, however, it is frequently found that a large number are dead. This is especially true if the maggots have just died and discoloration has not yet taken place. After retardation by low temperature or after prolonged nutritional retardation many maggots may die and

disintegrate. The diminution in the number of live maggots in this manner is not readily noticeable, as even 100 or 200 live maggots in a bottle appear to be a great number.

Amount of Necrotic Tissue Removed.—In the final anlysis of the effect of retardation on the therapeutic value of maggots, the quantity of necrotic tissue which they can remove from the wound is of primary importance. A unit of 100 newly hatched maggots removed 6.4 Gm. of tissue after three days of nutritional retardation (table 2). In reality, 100 living maggots would remove more than this, but as there is a slight mortality through retardation, less than this number were available. The usual osteomyelitic wound may require an implantation of 500 maggots, and in this case 32 Gm. of necrotic tissue would be removed. On the other hand, 500 specimens retarded by low temperature for three days, which includes the period during the tests of sterility, were able to remove only 9 Gm. of tissue.

TABLE 3.—*Effect of Nutritional Retardation on Length of Feeding Time of Maggots on Necrotic Tissue*

	Percentage of Maggots Ceasing Feeding After				
Retardation Period, Days	Two Days	Three Days	Four Days	Five Days	More Than Five Days
3	0.0	4.2	94.5	0.4	0.9
5	0.0	5.1	91.0	2.5	1.4
6	0.08	14.4	75.4	8.2	1.9
7	0.4	4.1	62.7	22.0	10.8
8	0.2	7.1	29.4	39.0	24.3
9	0.0	3.1	29.1	39.5	28.3

After five days the amount consumed per hundred maggots was 6 Gm.; after six days, 5.1 Gm., and after seven days, 4.8 Gm. Even after eight days over one half of the potential feeding capacity of the maggots was still available. It is interesting to note that even after nine days the therapeutic value of the maggots was still considerable, while with retardation by low temperature the value practically ceased to exist after three days.

On account of the excessive serous exudation of the wound which is stimulated by the presence of the maggots, a certain amount of necrotic tissue is discharged from the wound with the drainage. This could not be determined by the method used. The data shown, therefore, probably do not represent the maximum amount of tissue removed.

Duration of Feeding in the Wound.—The length of time that surgical maggots are usually allowed to feed in the wound is from three to four days. A few still feed if left for five days. It is shown in table 3 that nutritionally retarded maggots were able to feed for the required period, and this has been confirmed by numerous clinical tests. The duration

of feeding and the large number that survive under this method increase the therapeutic value of such maggots.

APPLICATION OF NUTRITIONAL RETARDATION

In the Laboratory and Hospital.—Both labor and expense in maggot culture can be reduced by nutritional retardation. This method restrains the growth and development of maggots during the sterility tests with the minimum amount of injury. It also permits maggots to be held for several days after they are ready for use, which eliminates the need of sterilizing eggs daily to maintain a continuous supply of specimens, since sterilization twice a week is sufficient.

After the maggots are received at the hospital the surgeon is frequently unable to use them promptly; it is therefore convenient and economical to be able to hold them over until needed. This can be done when maggots are retarded nutritionally but not when they are retarded by low temperature.

During Transit.—When only a few maggots are required, they are usually purchased from certain pharmaceutic supply houses, and frequently they have to be shipped for long distances. Retardation during transit has been attempted chiefly by packing in ice, but this method has been proved inefficient.[6] Experiments have been conducted on nutritional retardation during transit, not only in the laboratory but in actual practice. Surgical maggots were shipped from Washington, D. C., to New York, Pennsylvania, Ohio, Iowa, North Dakota, Oregon, California, Texas and Alabama. The time spent in transit varied from three to eight days, and in every instance but one[7] the maggots were reported to be alive and active on arrival and able to feed for four or five days after being transferred to necrotic tissue. Maggots have also been kept in the laboratory in which this investigation was made for a week or longer and then used in human wounds at hospitals in Washington with excellent results.

When this method of shipping is employed, all the necessary packing is accomplished by simply wrapping the bottle of maggots in a layer of cellulose and inserting it into a carton for mailing. The postage on such a package is comparatively low, the weight being only about one-eighth that of iced packages. The excessive material and labor used in making up the iced package are also rendered unnecessary.

Nutritional retardation, therefore, seems applicable to various phases of maggot culture requiring the restrained growth and development of the maggots, and it makes the cultural process more simple, efficient and economical.

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7. For some unknown reason the maggots in one bottle were dead on arrival at Ames, Iowa.

SUMMARY

A retardation-inducing food, consisting of evaporated milk, agar and water, has been devised which eliminates the necessity for the customary method of retardation by low temperature, both during the sterility tests and during transit.

Tests were conducted to determine the rate of growth and development during nutritional retardation; it was found that both processes could be retarded for eight or nine days without serious injury. This possibility permits surgical maggots which are not needed immediately to be held for later use. It also enables long distance shipments to be made efficiently and with the minimum expense and labor.

A study has been made of the amount of necrotic tissue removed from the wound by maggots after various periods of nutritional retardation. This quantity is vastly greater than when retardation by low temperature is used. The therapeutic value of the maggots is thus greatly increased, as removal of necrotic tissue is apparently one of the principal factors in the value of this treatment. The amount removed varies inversely, however, with the length of the period of retardation, owing to the increased mortality. The period of feeding following retardation is from four to five days, and the maggots have a tendency to feed longer after an extended period of retardation than when growth has been arrested for only a short period.

Practical tests were conducted on shipments of nutritionally retarded maggots for long distances. Specimens mailed to various parts of the United States were reported as received in good condition and as feeding for four or five days after being transferred to necrotic tissue.

PERITONEAL DRAINAGE

RESISTANCE OF SINUS TRACT TO INFECTION

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Drainage of the peritoneal cavity has been shown to be a futile and, in fact, a harmful procedure in many of the conditions in which it was formerly advocated. There remain, however, three definite indications for the use of drains in the abdominal cavity: first, to control bleeding by the hemostatic effect of a foreign body; second, to provide an outlet for a localized infection of the peritoneal surface and thus to prevent formation of abscesses, and third, to produce a sinus tract through which substances may escape from a walled-off area within the abdomen without soiling the general peritoneal surfaces. In the third instance it is of considerable importance to know how soon the sinus tract forms and how soon the tissues comprising its walls become impervious to the passage of pathogenic organisms.

A number of investigators have shown that a foreign body left as a drain in the abdomen is shortly encapsulated by adherence of the surrounding peritoneal surfaces, so that the drain no longer communicates with the general peritoneal cavity. In 1905 Yates [1] made an admirable study of this problem in the dog. He observed that either gauze or rubber protective was entirely encapsulated within six hours and that the adhesions had become organized to form a structural tract at the end of three days. It is a familiar clinical observation that the abdominal sinus which remains after the removal of the drain a week or ten days postoperatively is just as resistant to infection as any other granulating wound. The number of days, however, that the drain must remain before the sinus tract can safely be exposed to pathogenic organisms has not been determined. The following experiments were undertaken to elucidate this point.

METHOD OF INVESTIGATION

A virulent strain of Bacillus coli, secured from the department of pathology of the Peter Bent Brigham Hospital, was passed through a number of guinea-pigs until it had attained sufficient virulence to kill the pig within twenty-four hours after the intraperitoneal injection of 1 cc. of a twenty-four hour culture (approxi-

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From the laboratory of Surgical Research, Harvard Medical School.

1. Yates, J. L.: An Experimental Study of the Local Effects of Peritoneal Drainage, Surg., Gynec. & Obst. **1**:473, 1905.

mately 500,000,000 organisms per cubic centimeter). A description of the experimental procedure follows.

The abdomen was shaved and cleansed with ether and 70 per cent alcohol. A small incision was made in the midline through the skin, muscle and peritoneum, and the layers of the abdominal wall on either side were approximated by silk sutures. A tube of gum rubber, 8 mm. in diameter, was inserted 3 cm. into the abdominal cavity, and a sterile dressing was held in place over the tube by an adhesive binder. At varying intervals after operation the tube was removed, the character of the sinus tract was noted and 1 cc. of the twenty-four hour culture of B. coli was introduced into the tract. The dressing was then reapplied. If the animal subsequently died, cultures were made of material obtained from the peritoneum through an incision made under aseptic precautions some distance from the sinus. If the animal was still alive after four days, it was killed, and similar cultures were made.

Similar experiments were carried out in a limited number of dogs. The culture used in these experiments was obtained from an animal dying of peritonitis induced by making a gaping incision in the lower part of the colon. Studies used as controls showed that, whereas as much as 50 cc. of this culture injected intraperitoneally was required to kill a dog, the peritoneal cultures remained positive as long as six days after the injection of 10 cc.

RESULTS

The nature of the sinus tract was observed at the following stages: At the end of twenty-four hours, removal of the tube left no visible tract. The intestine closed in and tended to bulge out of the wound on straining. In forty-eight hours a poorly formed tract was apparent, though the intestine still tended to protrude on straining. After three days a definite sinus tract had formed which did not collapse on removal of the tube.

In the first series, consisting of eight animals, the tube was removed on the first, second, third and fourth days after insertion, and a tight dressing was applied. All the animals survived, and the culture material obtained from the peritoneum four days after removal of the tube was negative in each instance.

In the second series, consisting of ten animals, the tube was removed after twenty-four hours, and 1 cc. of the culture was injected into the wound. Four pigs died and six survived until the fourth day. The cultures of peritoneal material obtained from three of these animals were positive, and those from three were negative.

In the third series the tube was removed after forty-eight hours, and an injection of the culture was made into the wound. One of the ten pigs died, and nine survived till the fourth day. The cultures of peritoneal material obtained from two of the nine pigs were positive, and those from seven were negative.

In the fourth series, the tube was removed after three days and an injection of the culture was made into the sinus. All ten pigs survived

till the fourth day, when cultures of peritoneal material yielded one positive and nine negative results.

In the fifth series, the tube was removed after four days and an injection of the culture was made into the sinus. All ten pigs survived, and the cultures of peritoneal material obtained on the fourth day were all negative.

In the sixth series, the tube was removed after five days and a portion of the culture was injected into the sinus. All five pigs survived, and the cultures of peritoneal material on the fourth day were all negative.

In the seventh series four dogs were used. The tube was removed, and 10 cc. of culture was injected into the tract on the second, third, fourth and fifth days, respectively. Cultures of material from the peritoneum obtained two days later were negative except in the case of the first dog.

COMMENT

It is seen that the resistance of the sinus tract rapidly increased, becoming complete by the fourth day. There was considerable resistance on the second day, in spite of the fact that the tract was so poorly formed that in most instances it was disrupted by removal of the tube. This may have been due to an increased local peritoneal resistance, resulting from the irritation of the foreign body.

It is interesting to compare the resistance of the peritoneal sinus to infection with that of healing sutured wounds of the skin and abdominal wall. The resistance of the latter type was worked out by DuMortier [2] in guinea-pigs, using a virulent strain of Staphylococcus haemolyticus. He determined that there was a rapid increase in resistance, so that by the fifth day it was comparable to that of intact skin. On the third day implantation of cultures of staphylococcus on the surface caused infection in 36 per cent of the animals, and on the fourth day in 10 per cent. Our results showed a slightly more rapid acquisition of resistance in the case of the peritoneal sinus. However, the fact must be considered that it takes, as a rule, a much larger number of organisms to infect the peritoneum than it does to cause an infection in the abdominal wall; hence a few organisms may have made their way through the wall of the sinus into the peritoneal cavity but were destroyed there by the time the animal was killed and a culture obtained.

From the foregoing observations it may be concluded that an abdominal drain of smooth rubber or rubber tissue may be safely removed after the third day without danger of infecting the general peritoneal cavity either by infection from without or by the evacuation

2. DuMortier, J. J.: The Resistance of Healing Wounds to Infection, Surg., Gynec. & Obst. **56**:762, 1933.

of infected material along the sinus tract from within. This would probably not hold true in the case of drains in which there is exposed gauze, for with this type early removal disrupts the sinus tract. However even in this case, local peritoneal immunity would probably tend to prevent the spread of infection.

Certain clinical deductions may be drawn from the experimental study of the reaction of the peritoneal surfaces to drains. When the drain is inserted in a clean case to control bleeding, it should be removed prior to the third day or before a structural tract has formed, and this removal should be performed under strictly aseptic precautions. If the drain is allowed to remain longer than the third day, the resulting sinus tract may become infected, and, though there is little danger of infecting the general peritoneal cavity, convalescence is unnecessarily prolonged. When the drain is inserted to produce a sinus tract through which an underlying abscess may later be evacuated extraperitoneally, the drain may be removed as early as the third day, but preferably on the fourth or fifth day, and the abscess may be ruptured through the resulting sinus tract. The tract must, of course, be kept open by the reinsertion of a suitable piece of rubber tissue or tubing until the abscess has healed in. When the drain is inserted in infected peritoneal surfaces in which one suspects that an abscess would form if drainage were omitted, the drain should not be removed before the fourth day or before a structural tract is formed, and the tract must, of course, be kept open until it heals in from the bottom.

Furthermore, certain conclusions may be drawn as to the type of drain which should be employed. Exposed gauze should be avoided whenever possible. When the drain is for the control of bleeding and the hemostatic effect of the gauze is required, the "cigaret" type of drain should be employed and care be taken that only the gauze which is in direct contact with the bleeding tissue is left uncovered by the rubber casing. When the drain is inserted to provide an extraperitoneal outlet for infected material, a simple rubber tube is preferable. This tube should be smooth and soft but sufficiently rigid to produce a tract of suitable diameter to allow for subsequent irrigations.

Except for the control of bleeding, there seems to be little value in the incorporation of gauze in abdominal drains. For a few hours the gauze conveys serous exudate to the surface, but after that period it serves only as a plug to dam back purulent material which would find its way out through a simple rubber tube.

PENETRATION OF MOIST HEAT APPLIED TO THE ABDOMEN AND ITS EFFECT ON INTESTINAL MOVEMENTS

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The use of heat in the treatment of abdominal conditions, particularly peritonitis or localized abscesses, has become a frequent procedure in hospitals. Patients as a rule state that they feel better when such treatment is instituted, and the relief from pain which heat affords in intestinal or pelvic conditions is commonly known.

Some conflict of opinion is evident in the literature concerning the effect of heat applied locally to the abdomen. Among those who have found a rise in temperature within the abdomen after the application of heat to the outside of the abdomen are von Ewald,[1] von Brieger,[1] Wendriner,[1] Winternitz[2] and Eichler and Schemel.[3] These authors used hot steam or jets of hot water to induce the increase in temperature. Chelmonski,[1] using hot water bottles, induced a rise of 2 C. within the abdomen, while Stengel and Hopkins,[4] using the same method, found the results negligible. Hepburn and his associates,[5] using hot water bags, hot wet packs, electric pads, irradiation with infra-red rays and diathermy, were unable to increase intragastric temperature after applying heat for one hour or longer, except with diathermy, by which a rise of 1 F. was noted. No studies recording the effect of heat on intestinal movements have been found in the literature.

From the University of Kansas School of Medicine.

1. Quoted by Eichler and Schemel.[3]

2. Winternitz, W., et al., in Cohen, S. S.: System of Physiologic Therapeutics, Philadelphia, P. Blakiston's Son & Company, 1902, vol. 9, p. 248.

3. Eichler and Schemel: Ueber die Beeinflussung der Magentemperatur durch verschiedene hydrotherapeutische Applikationen und ihre Messung mit dem Fieberregistrierapparat, Deutsche med. Wchnschr. **37**:2371, 1911.

4. Stengel, A., and Hopkins, A. H.: A New Method for Determining the Intragastric Temperature in Man with Some Observations on Its Variations After Ingestion of Hot and Cold Liquids and During Digestion, Am. J. M. Sc. **153**: 101, 1917.

5. Hepburn, J. S.; Eberhard, H. M.; Ricketts, A., and Rieger, C. L. W.: Temperature of the Gastro-Intestinal Tract: The Effect Thereon of Hot and Cold Foods and of Physical Therapeutic Agents, Arch. Int. Med. **52**:603 (Oct.) 1933.

EXPERIMENTS

Heat was applied to the abdomen by using two thicknesses of moist flannel beneath an insulated rubber electric pad. The heating system was covered with a layer of rubber sheeting to prevent the loss of heat. The heat was usually applied for one hour and in some experiments for three hours. The temperature of the pack ranged between 106 and 109 F. at its point of contact with the skin.

The first ten determinations were made on two mature dogs weighing 10 Kg. each by taking the temperature with a long thermometer through the anus in the midcolon and in Thiry-Vella jejunal loops with the same mercury thermometer before and after heat had been applied for one hour. The abdomen of each animal was shaved, and the dogs were allowed to be in the room in which the experiments were carried out for at least an hour. The animals had had no food for at least twelve hours before the experiment was begun. The body temperature was taken through a slit in the axillary fold.

Fifteen determinations were made on three adult patients by taking the temperature in colostomy openings before and after the application of heat for one hour. The oral temperature was also recorded. Five observations were similarly made on a 9 year old child weighing 25 Kg. to determine the difference in effect produced by the thickness of the abdominal wall. These determinations were compared with five determinations made on a dog which weighed 25 Kg. Five observations were made on an adult having an infected suprapubic cystostomy wound to determine any difference in the conduction of heat between infected and non-infected areas. In each of the five patients studied the effect of heat applied for three hours was also observed.

The effect of heat on intestinal contractions was studied in the dog by applying heat to the abdomen and recording intestinal contractions on a smoked drum by means of a jejunal Thiry-Vella loop and a Brodie bellows. Heat was also applied by injecting warm water directly into the Thiry-Vella loop.

RESULTS

The application of heat to the abdomen of small dogs for a period of one hour resulted in an average rise in temperature within the intestine of 1.2 F. (table). In one experiment no increase was noted and in another a drop of 0.6 F. occurred. The average rise in body temperature for the ten animals was 0.5 F. The largest dog showed an average increase of 0.9 F. in the intestine and a rise in body temperature of 0.3 F.

The experiments on adult patients with colostomies showed only a slight tendency to an increase of the temperature in the intestine. In eight of the experiments there was either no change or a drop in the temperature within the intestine. A small average rise of 0.2 F. was noted, with an average rise of body temperature of 0.1 F. The results on the child, however, were more definite: An average rise of 0.8 F. was noted.

The presence of infection did not seem to have any influence in either increasing or decreasing the penetration of heat. The average rise within the suprapubic cystostomy wound was 0.3 F.

The application of heat for a period of three hours did not significantly increase the intra-abdominal temperature in adults. In one patient the temperature remained unchanged after three hours. The child showed, however, a definite rise after a three hour period.

Kymographic tracings of the jejunum of the dog with the same heat applied to the abdomen as in the other experiments or with the appli-

Comparison of Changes in Temperature (F.) After Moist Heat Had Been Applied to the Abdomen for One Hour to Show the Difference in Penetration Through Thick and Thin Abdominal Walls

		Temperature		Experiment 1	2	3	4	5	Average Rise in Temperature
Dogs; weight, 10 Kg.	1	Abdominal	Before	102.0	103.6	104.0	102.2	103.6	Abdominal, 1.2
			After	103.2	106.2	105.4	103.6	104.6	
		Axillary	Before	100.5	102.2	103.8	100.5	102.6	
			After	100.8	102.6	104.2	101.8	101.8	
	2	Abdominal	Before	104.0	101.2	102.1	102.2	101.5	Body, 0.5
			After	105.5	103.0	102.1	101.6	103.4	
		Axillary	Before	103.6	100.3	100.0	99.4	101.1	
			After	104.1	101.1	99.8	99.6	102.1	
Adults; weight, 60 Kg.	1	Abdominal	Before	100.1	100.2	100.1	99.4	99.4	Abdominal, 0.2
			After	100.2	100.1	100.1	99.7	99.8	
		Oral	Before	99.4	99.6	99.6	98.7	98.6	
			After	99.7	99.6	99.3	98.7	98.6	
	2	Abdominal	Before	99.9	99.3	100.2	99.4	100.0	
			After	99.9	100.0	99.7	99.9	98.8	
		Oral	Before	99.2	98.8	99.0	98.9	98.9	
			After	99.3	99.1	98.9	99.0	98.9	
	3	Abdominal	Before	100.0	99.2	99.5	99.9	99.3	Body, 0.1
			After	100.0	99.6	99.4	99.9	99.4	
		Oral	Before	98.6	98.6	99.1	98.7	98.9	
			After	98.5	98.7	99.4	98.6	98.8	
Child; weight, 25 Kg.	1	Abdominal	Before	99.5	99.1	99.5	99.1	99.8	Abdominal, 0.8
			After	100.0	99.8	100.8	101.2	99.4	
		Oral	Before	99.2	99.3	99.1	99.4	99.2	Body, —0.4
			After	99.0	99.0	98.9	98.8	98.4	
Dog; weight, 25 Kg.	1	Abdominal	Before	101.0	102.5	101.1	101.5	101.4	Abdominal, 0.9
			After	101.6	103.8	102.0	102.0	102.5	
		Oral	Before	99.5	101.1	99.5	100.0	101.1	Body, 0.3
			After	99.8	101.5	100.1	100.1	101.5	

cation of warm water directly into the intestine at the same temperature showed no tendency to an increase or decrease of either intestinal tone or amplitude of contractions.

SUMMARY

Warm moist heat was applied to the abdomen of small and large dogs, adults and a child for periods of from one to three hours in a total of forty experiments, and the temperature was recorded either in the colon or in an intestinal fistula. The effect of heat on intestinal

contractions was noted in dogs with Thiry-Vella loops by the use of kymographic tracings.

It was determined that local applications of heat to the abdomen produce a rise in temperature within the abdomen if the abdominal wall is not too thick. Definite penetration was noted in the child and in the dogs, but the penetration in the adults was negligible. Prolonged application of heat did not increase the degree of penetration.

The application of heat to the abdomen or of warm water to the intestine did not affect intestinal tone or intestinal movements.

SUCTION WITH A NASAL CATHETER: ITS EFFECT ON THE BLOOD CHEMISTRY

REPORT OF A CASE

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Although articles in the literature dealing with continuous drainage of the intestinal tract through suction applied to an inlying nasal catheter are accumulating rapidly, there are at present very few. Although the duodenal tube was a prominent part of the surgeon's armamentarium and a device known as the Connell suction apparatus had been assembled, these aids were not united in therapeutic use until Ward,[1] in 1925, employed them in the treatment of "general peritonitis, postoperative ileus, intestinal obstruction and acute gastric dilatation" to prevent "that dilatation and sogginess of the upper intestinal tract which is so commonly found in cases of this type that come to postmortem examination."

Following this rather brief suggestion there was silence until 1932, when Wangensteen,[2] in a treatise on acute intestinal obstruction, reported the successful treatment of three patients with obstruction by means of continuous suction applied through a nasal catheter. Interest in the subject has since been increasing rapidly, and the literature now includes several excellent articles by Wangensteen and Bartlett and the works of Paine, Carlson and Benjamin. These last three authors have concerned themselves chiefly with the application of suction in the treatment of postoperative nausea, vomiting and distention, while Wangensteen and Bartlett have more particularly studied its use in cases of ileus and of obstruction of the bowel.

Suction applied through a nasal catheter is recommended by Paine, Carlson and Wangensteen [3] for use as a routine following operation

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This thesis was submitted to the faculty of Surgery of the Graduate School of Medicine of the University of Pennsylvania in partial fulfilment of the requirements for the degree of Master of Medical Science (M.Sc. [Med.]) for graduate work in Surgery.

1. Ward, R.: An Apparatus for Continuous Gastric or Duodenal Lavage, J. A. M. A. **84**:114 (April 11) 1925.

2. Wangensteen, O. H.: Early Diagnosis of Acute Intestinal Obstruction with Comments on Pathology and Treatment, with Report of Successful Decompression of Three Cases of Mechanical Bowel Obstruction by Nasal Catheter Suction Siphonage, West. J. Surg. **40**:1 (Jan.) 1932.

3. Paine, J. R.; Carlson, H. A., and Wangensteen, O. H.: Postoperative Control of Distention, Nausea and Vomiting: Clinical Study with Reference to Employment of Narcotics, Cathartics, and Nasal Catheter Suction-Siphonage, J. A. M. A. **100**:1910 (June 17) 1933.

on the biliary tract and gastric or intestinal operation, and Paine [4] recommended it in any case of postoperative distention with or without nausea and vomiting. Paine [4] further stated that patients who have undergone appendectomy or an operation for hernia probably have less nausea and vomiting and require fewer enemas when subjected to the intestinal decompression, but he expressed the belief that the advantages are too few to warrant its use, since it means retention of the tube in the nose for several days and a postponement of the return to fluids and food by mouth.

The indications for the use of suction by means of the nasal catheter in cases of obstruction of the bowels are clearly defined by Wangensteen and Paine [5] and include simple obstruction of the small intestine, spastic ileus and paralytic ileus. The authors are especially careful to insist that the chief contraindication is strangulation. Wangensteen [6] added: "Adhesive bowel obstruction is especially amenable to treatment by this method, whether the causative adhesive obstructing mechanism is of recent (postoperative) or remote origin."

While Wangensteen and Paine, with faith in the ileocecal valve, included among their contraindications cases in which an obstruction in the left colon caused dilatation of the proximal portion of the large bowel, Bartlett [7] disagreed, stating the belief that even here decompression may be effected, since at times the ileocecal valve is incompetent.

This paper was prepared in an effort to determine the effect of continuous duodenal drainage on the physiologic status of the organism and especially its effect on the quantity of chlorides in the blood and the carbon dioxide-combining power of the plasma. It was felt that dehydration could be studied by observing the changes in the concentration of the blood and in the urinary output. And, finally, an effort was made to determine an adequate means of combating the changes which might occur.

The apparatus used was in principle the same as that described by Wangensteen.[2] For some patients whose gastric contents were particularly thick and especially for patients with an emergency case who were not properly prepared it was found advantageous to use, instead of the routine no. 16 F Levine catheter, one of larger caliber, namely, no. 18 F. The larger catheter was tolerated just as well.

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4. Paine, J. R.: Constant Suction by Nasal Catheter as an Adjunct in Postoperative Treatment, Minnesota Med. **15**:444 (June) 1932.

5. Wangensteen, O. H., and Paine, J. R.: Treatment of Acute Intestinal Obstruction by Suction with Duodenal Tube, J. A. M. A. **101**:1532 (Nov. 11) 1933.

6. Wangensteen, O. H.: Therapeutic Considerations in the Management of Acute Intestinal Obstruction, Minnesota Med. **15**:556 (Aug.) 1932.

7. Bartlett, W., Jr., in discussion on Wangensteen and Paine.[5]

In the patients under observation, samples of blood were taken immediately before the operation. At the same time a specimen of urine was collected for examination. When the patient had reacted from the anesthetic sufficiently to swallow, the Levine catheter was passed through the nose and suction was instituted. At the same time, para-oral fluids, if any were to be used, were administered. No attempt was made to measure the amount of fluids taken by mouth nor the amount of fluids or gas recovered from the stomach. Morphine was given when necessary. To alleviate the irritation of the tube in the nose, 1 drop of 0.5 phenol in oil was dropped into each nostril every six hours, as suggested by Bartlett.[8] A 0.5 to 1 per cent solution made by dissolving several lozenges of ethylaminobenzoate in water was sprayed in the throat occasionally; it seemed to afford relief.

At the end of a twenty-four and a forty-eight hour period following the insertion of the nasal catheter, blood and urine were collected for study. The blood for the determination of the carbon dioxide-combining power was taken under oil and tested according to the method of Van Slyke. The blood chlorides were determined as outlined by Whitehorn. A modified Sahli technic was used in recording the hemoglobin.

In table 1 are outlined the results of duodenal drainage for forty-eight hours for thirteen patients, twelve of whom were operated on for a pathologic condition of the gallbladder or appendix. The thirteenth, Robert T., who was an ambulant patient with osteomyelitis, consented to drainage so that the list would include a near-normal person.

Under the column "Ketones in the Urine" are listed the values for acetone and diacetic acid as they appeared in the urine. The total amount of urine excreted in forty-eight hours is recorded, as is the amount of morphine required to control the pain. The maximum temperature and pulse readings are given. In this first group, no para-oral fluids were given. The patients drank water ad libitum so long as it returned immediately through the nasal tube.

In table 2 are recorded the results obtained in four cases in which fluids were given in the form of continuous venoclysis, either of saline solution and dextrose or of saline solution alone.

Table 3 shows the results in two cases in which the patients were given hypertonic (3 per cent) saline solution continuously by the intravenous route.

Table 4 shows the results when continuous hypodermoclysis was employed. In the last group (table 5) the material collected from the intestinal tract was placed in the rectum in the form of a 6 ounce (180 cc.) retention enema every four hours. The patients were limited to

8. Bartlett, W., Jr.: The Concept of Pyloric Balance in Ileus Treated by Continuous Suction from the Stomach, Am. J. Surg. **23**:484 (March) 1934.

TABLE 1.—*Results of Duodenal Drainage for Forty-Eight Hours in Patients to Whom No Para-Oral Fluids Were Given*

Patient	Age	Operation	Time	Sodium Chloride of the Blood	Carbon Dioxide, Volume per Cent	Hemoglobin, Gm.	Red Blood Cells	Ketones in the Urine	Total Urine, Cc.	Morphine Sulphate Required, Grains	Temperature, F.	Pulse Rate
Robert T.	21	None	Preoperative	445	68.3	12.2	3,670,000					
			24 hours after	379	70.2	13.9	4,550,000	+++, +++	400	1/4	98.3	96
			48 hours after	330	79.6	14.4	4,560,000					
William R.	40	Cholecystectomy	Preoperative	379.5	68	15.3	4,940,000					
			24 hours after	247	72.7	16.7	5,700,000	.....	1,380	2/6	100.3	128
			48 hours after	254	74.9	15.3	6,060,000					
Betty T.	21	Appendectomy	Preoperative	379	68.1	15.5	4,640,000					
			24 hours after	396	79.6	14.7	4,820,000	.....	1,650	3.6	100.2	116
			48 hours after	379	79.6	16.2	4,770,000	+++				
Rose D.	29	Appendectomy	Preoperative	396	55.1	13.7	4,400,000					
			24 hours after	379.5	57	16	4,670,000	++++	510	2/4	100	102
			48 hours after	379.5	70.2	13	5,280,000	+++, +				
Grace C.	28	Appendectomy	Preoperative	412	66.4	15.8	5,430,000					
			24 hours after	346.5	74	15.8	4,740,000	++++, +++	1,620	2/4	100	106
			48 hours after	346.5	77.7	17	5,500,000					
Nancy D.	19	Appendectomy	Preoperative	412	64.5	14.9	4,470,000					
			24 hours after	429	64.3	13.7	4,340,000	+++	1,380	1/6	98.4	126
			48 hours after	379	70.2	16	5,020,000	+++				
Mary D.	34	Appendectomy	Preoperative	429	58.9	12.2	5,010,000	No specimen				
			24 hours after	396	57	14.8	4,500,000	+++	840	2/6	100.2	116
			48 hours after	297	64.5	15.5	5,190,000	++++, +++				
Louise S.	17	Appendectomy	Preoperative	412	58.9	14.9	4,640,000					
			24 hours after	363	66.4	17.2	5,920,000	+++, +	1,650	1/6	99.2	92
			48 hours after	363	62.6	17.4	5,590,000					
Jean M.	24	Appendectomy	Preoperative	396	46.6	12.8	4,580,000	+				
			24 hours after	379	64.5	15.7	4,430,000	No specimen	1,140	2/6	100.2	116
			48 hours after	297	64.5	17.2	4,690,000	+++, +++				
Elizabeth T.	36	Cholecystectomy	Preoperative	379.5	68.3	17	4,800,000	No specimen				
			24 hours after	363	55.1	17.4	5,210,000	+	690	1/4	100	124
			48 hours after	412.5	51.3	15.8	4,720,000	+++				
Laura L.	24	Appendectomy	Preoperative	495	64.5	15.8	4,340,000	No specimen				
			24 hours after	495	49.4	11.8	4,320,000	No specimen	1,650	1/6	100	92
			48 hours after	412.5	51.3	15.1	5,950,000	+++, ++				
Mary F.	16	Appendectomy	Preoperative	462	41.4	17.4	5,160,000	++++				
			24 hours after	412.5	60.7	16	4,720,000	+++	780	2/6	99.2	120
			48 hours after	429	74	14.8	4,570,000	+				
Betty D.	33	Appendectomy	Preoperative	412.5	61.6	14.7	4,570,000	+++				
			24 hours after	396	55.1	16.7	4,430,000	No specimen	810	1/4 and 1/6	101.4	116
			48 hours after	379.5	68.3	13.4	4,510,000	+++				

TABLE 2.—*Results of Duodenal Drainage for Forty-Eight Hours in Patients Who Received Continuous Venoclysis*

Patient	Age, Years	Operation	Total Amount of Fluid Given	Time	Sodium Chloride of the Blood	Carbon Dioxide, Volume per Cent	Hemoglobin, Gm.	Red Blood Cells	Ketones in Urine	Total Urine, Cc.	Morphine Sulphate Required, Grains	Temperature, F.	Pulse Rate
Anthony V.	36	Cholecystectomy	Saline solution with 5 per cent sugar, 5,000 cc.	Preoperative	363	68.3	14.9	5,010,000	.....	1,530	2/4	100.4	108
				24 hours after	445	53.2	14.4	4,950,000					
				48 hours after	462	68.3	13.7	3,920,000					
Freda H.	21	Ovarian cyst and appendectomy	Saline solution with 5 per cent sugar, 7,000 cc.	Preoperative	396	63.4	13.7	4,580,000	+	2,100	3/4	100.4	118
				24 hours after	445	65.5	10.4	5,000,000	Sugar +				
				48 hours after	462	72.1	12	4,020,000					
Helen C.	21	Appendectomy (perforated)	Saline solution, 3,800 cc., and sugar 100 Gm.	Preoperative	429	58.6	13	4,110,000	+++, ++	1,920	3/6	102	120
				24 hours after	495	66.4	11.7	4,190,000	++++				
				48 hours after	511	62.6	11.3	4,660,000	+++				
Herbert W.	23	Appendectomy (perforated)	Saline solution, 4,000 cc.	Preoperative	412	81.5	16.9	5,060,000		2,190	3/4	101	104
				24 hours after	330	85.7	16.2	5,000,000	.....				
				48 hours after	313	74.9	14.3	4,650,000					

TABLE 3.—*Results of Duodenal Drainage for Forty-Eight Hours in Patients Who Received Continuous Venoclysis with 3 Per Cent Saline Solution*

Patient	Age, Years	Operation	Total Amount of Fluid Given	Time	Sodium Chloride of the Blood	Carbon Dioxide, Volume per Cent	Hemoglobin, Gm.	Red Blood Cells	Ketones in Urine	Total Urine, Cc.	Morphine Sulphate Required, Grains	Temperature, F.	Pulse Rate
Helen B.	18	Appendectomy	Sugar, 25 Gm., and 3 per cent saline solution, 2,600 cc.	Preoperative	495	60.5	12.8	4,780,000	++	2,190	2/6 and 1/4	101.4	112
				24 hours after	495	58.9	12.2	4,270,000					
				48 hours after	379	62.6	9.2	3,360,000					
Helen S.	52	Appendectomy	Sugar, 25 Gm., and 3 per cent saline solution, 2,900 cc.	Preoperative	445	70.2	16.7	5,270,000	+	2,190	2/6	102.4	128
				24 hours after	412	57	14.1	4,920,000					
				48 hours after	330	47.5	12.2	3,820,000					

TABLE 4.—*Results of Duodenal Drainage for Forty-Eight Hours in Patients Who Received Continuous Hypodermoclysis*

Patient	Age, Years	Operation	Total Amount of Fluid Given	Time	Sodium Chloride of the Blood	Carbon Dioxide, Volume per Cent	Hemoglobin, Gm.	Red Blood Cells	Ketones in Urine	Total Urine, Cc.	Morphine Sulphate Required, Grains	Temperature, F.	Pulse Rate
Mary L.	65	Cholecystectomy	Saline solution, 2,600 cc.	Preoperative	489	72.1	14.1	4,110,000					
				24 hours after	396	78.7	13.6	4,500,000	.....	1,110	1/4	101.1	132
				48 hours after	445	56	13.4	4,560,000	+				
Mary G.	50	Cholecystostomy and appendectomy	1 per cent sugar solution, 3,000 cc., and saline solution, 5,200 cc.	Preoperative	396	62.4	12.8	4,560,000					
				24 hours after	412.5	54.1	12.2	5,010,000	.....	1,170	3/4	100.3	136
				48 hours after	429	69.9	13.9	4,510,000					
Regina K.	27	Appendectomy	Saline solution, 3,000 cc.	Preoperative	478.5	66.4	16.2	4,420,000					
				24 hours after	478.5	71.1	13	4,430,000	No specimen	930	1/6	100	100
				48 hours after	396	66.4	13.7	4,600,000	++++, ++				

TABLE 5.—*Results of Duodenal Drainage for Forty-Eight Hours in Patients Whose Intestinal Drainage was Replaced in the Rectum*

Patient	Age, Years	Operation	Total Amount of Fluid Given	Time	Sodium Chloride of the Blood	Carbon Dioxide, Volume per Cent	Hemoglobin, Gm.	Red Blood Cells	Ketones in Urine	Total Urine, Cc.	Morphine Sulphate Required, Grains	Temperature, F.	Pulse Rate
Mary F.	19	Appendectomy	Drainage material in rectum, 1,800 cc.	Preoperative	396	60.7	14.2	4,730,000	No specimen				
				24 hours after	412.5	55.1	13.6	4,810,000	.....	1,740	2/6	100	120
				48 hours after	379	70.2	13	4,300,000	++				
Dolores H.	21	Appendectomy	Drainage material in rectum, 1,800 cc.	Preoperative	429	58.9	16.5	4,430,000					
				24 hours after	511.5	66.4	12.2	4,240,000	+	720	0	99.3	102
				48 hours after	379.5	70.2	13.9	5,350,000	++				
Gertrude D.	16	Appendectomy	Drainage material in rectum, 1,800 cc.	Preoperative	445	60.7	13.9	4,710,000	+++				
				24 hours after	330	64.5	13.9	4,520,000	++	1,620	0	98.4	116
				48 hours after	330	60.6	14.8	4,270,000					

8 ounces (240 cc.) of water an hour by mouth, so that the material aspirated would not be diluted too much. The intestinal contents were collected in a bottle inserted in the circuit, and the amount required was withdrawn when necessary, strained, heated and given as an enema.

In an analysis of the results shown in table 1 it is seen that the patients almost uniformly suffered a drop in blood chlorides and an elevation of the carbon dioxide-combining power. The blood became concentrated, as evidenced by the rise in the hemoglobin content and in the number of red cells. Ketones appeared in the urine, in spite of the alkalosis. In their book on biochemistry Trumper and Cantarow [9] explained this as being due (in obstruction of the pylorus and the upper part of the intestinal tract associated with continued vomiting) possibly to starvation and privation of carbohydrates, but, they added: ". . . in all forms of alkalosis it is probable that the diminution in hydrogen-ion concentration diminishes carbohydrate utilization in the tissues and thus interferes with the normal combustion of fatty acids in a manner similar to that operating in diabetes mellitus."

The total amount of urine voided by these patients daily was in only four cases more than the 700 cc. that Bartlett [8] mentioned as the upper border of dehydration.

As dehydration advanced and the patients leaned toward alkalosis, the majority showed flushed faces and marked thirst; otherwise the changes produced no symptoms. All the patients were comfortable abdominally, showing no distention, nausea or vomiting. Carlson and Orr,[10] in an article describing an experiment in which high intestinal obstruction was produced in dogs, reported the changes in the blood in the animals which were fed water and in those which were not and concluded that, in spite of the changes in the blood, which are more marked in the former group, "continuous lavage of the stomach in acute intestinal obstruction is a beneficial part of the treatment."

The four patients data for whom are given in table 2 were in a more serious condition than the others and were subjected to continuous venoclysis. As may be seen, although the carbon dioxide-combining power still showed a rise toward alkalosis, the administration of saline solution had caused a rise in the chloride content of the blood and had eliminated the dehydration. Herbert W., in a state of definite alkalosis on admission, showed this condition corrected under the administration of saline solution.

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9. Trumper, M., and Cantarow, A.: Biochemistry in Internal Medicine, Philadelphia, W. B. Saunders Company, 1932, p. 203.

10. Carlson, H. E., and Orr, T. G.: Experimental Obstruction of Jejunum: Effect of Administration of Water on Length of Life and Changes in Chemical Composition of Blood, Arch. Surg. **28**:292 (Feb.) 1934.

Even the administration of a 3 per cent saline solution did not check the drop in the blood chlorides in the two patients data for whom are shown in table 3. The intake of fluid apparently was adequate, since there was no evidence of dehydration. The thirst evidenced by these patients was even more marked than that evidenced by the others.

Continuous hypodermoclysis to some extent controlled the changes in the blood, as shown in table 4, and the changes in the red blood cell count and in the hemoglobin were not so marked as those shown in table 1, but the urinary output was diminished. Mary L. at the end of forty-eight hours of drainage started to have severe fibrillation and for twenty-four hours required infusions of 10 per cent dextrose solution and digitalis by mouth. The heart assumed normal rhythm again, however, in thirty-six hours. The mishap perhaps was due to an alteration in the volume of blood.

Finally, as suggested by Roberts,[11] the drainage material was introduced into the rectum every four hours (table 5). No rectal irritation was caused, and litmus paper showed that the specimens were either acid or neutral. The dehydration in two of the three cases was apparently controlled, and there was an initial rise in the amount of blood chlorides in two, but between the twenty-four and the forty-eight hour period specimens the chloride content fell. Possibly this was due to dilution of the material by water, which was drunk at the rate of 8 ounces an hour. These three patients appeared more comfortable than any of the others, and two required no sedative during their postoperative course.

The following is the report of a case of obstruction of the bowel of the adhesive type in a patient who recovered under therapy with suction:

REPORT OF A CASE

Ralph N., a Negro boy aged 12, was admitted to the hospital on Jan. 28, 1934, and a provisional diagnosis of acute appendicitis was made. He had an abdominal scar on the right side near the umbilicus which was said to be the result of an operation for the removal of a safety pin which he had swallowed when an infant. He was operated on immediately, and an acutely inflamed appendix was removed. The small intestine was rather markedly distended and was firmly adherent to the abdominal wall at the site of the former operation. These adhesions were freed, but during the procedure large areas of visceral peritoneum were torn from the bowel. The child's condition did not permit adequate exploration.

Twenty hours following operation the child vomited and the abdomen became distended. In spite of fair results from enemas, the vomiting and distention increased until fifty-one hours following operation, on January 30, a duodenal

11. Roberts, C. G.: Transduodenal Decompression and Reintroduction by Proctoclysis of Gastro-Intestinal Drainage in Acute Mechanical Ileus, J. A. M. A. **102**:1149 (April 7) 1934.

catheter was inserted through the nose and suction was applied. The vomiting ceased at once, and in three hours the abdomen was flaccid. Fluids were given by hypodermoclysis, and the child remained comfortable until February 1, when the tube was withdrawn because of a normal pyloric reflex.[12] For the next few days the distention was partially controlled by enemas; a soft diet was attempted, but after the first meal caused vomiting the child refused another and was again given only liquids. On February 6, the distention became so marked and vomiting was so persistent that the tube was again inserted and continuous venocylsis of 5 per cent dextrose in saline solution was begun. At this point the enemas were entirely ineffective; the distended coils of intestine were clearly visible through the abdominal wall, and peristalsis was apparent to the eye. The patient was comfortable from this time on. The tube was removed again on February 8, and a high compound enema was effective. A liquid diet was begun, and the venoclysis stopped, 4,000 cc. having been given in the two and a half days it was employed. The intestinal tract was kept open with liquid petrolatum. No further nausea, vomiting or distention occurred, and the patient was discharged in good health on February 22.

SUMMARY

The effect of continuous drainage of the stomach and duodenum through a nasal catheter was studied in twenty-five patients, twenty-four of whom were operated on.

Continuous suction applied through a nasal catheter causes a drop in the blood chlorides, an elevation of the carbon dioxide-combining power toward or into alkalosis, an elevation of the hemoglobin content of the blood and an increase in the red blood cell count.

The marked changes in the chlorides, hemoglobin and red cell content of the blood and the changed carbon dioxide-combining power accompanying continuous lavage of the upper intestinal tract produce few, if any, untoward symptoms.

Of the various methods of administering para-oral fluids, continuous venocylsis appears to be most effective in controlling the changes in the blood incident to continuous duodenal suction.

Administration of the aspirated intestinal contents in the form of retention enemas does not cause rectal irritation and deserves further study as a means of combating postoperative dehydration and the loss in chlorides and the alkalosis incident to obstruction of the bowels and continuous lavage of the stomach.

The use of a properly functioning nasal catheter with applied suction is an efficient way of controlling postoperative nausea, vomiting and distention and should be used prophylactically in cases in which this triad is anticipated.

A case of obstruction of the bowel of the adhesive type, of recent (or remote?) origin is reported, and the use of duodenal suction in the case is described.

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12. Bartlett, W., Jr.: The Changing Attitude Toward Ileus, Surg., Gynec. & Obst. **57**:702 (Nov.) 1933.

ACUTE PANCREATITIS

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Acute pancreatitis is an emergency condition that has interested the surgeon for many years. In spite of a large amount of study the results of treatment have not shown improvement in any degree comparable to that obtained in the case of many other abdominal diseases. From a study of the literature it is seen that the mortality rate varies between 40 and 80 per cent. During the last fifteen years, sixty patients with proved cases have been operated on at the Boston City Hospital. No report of an appreciably larger series has ever been published. This paper is based on a study of the literature and of these sixty cases.

ETIOLOGY

The hypotheses as to the etiology of acute pancreatitis presented by different students of the disease vary considerably. There has been a stereotyped classification of the etiology which practically every author recognizes, but there is no clearcut idea as to the importance of the different factors.

Pancreatic infection by the lymphatic route based on the anastomosis and relation of the lymphatics between the gallbladder and the pancreas (chiefly the head) has been given much consideration.

Pancreatic infection through the bile ducts has been considered important, and much reference has been made to it, proving that the injection of sterile bile, infected bile and the various bile salts into the pancreatic ducts results in acute pancreatic necrosis simulating the pathologic picture which is frequently seen at operation. Again, the etiology has been considered from the standpoint of duodenal contents being forced into or aspirated into the pancreatic ducts. Retrojection of bile due to spasm of the sphincter of Oddi is the hypothesis of Archibald. Again, the lodging of a gallstone in the ampulla of Vater, above which the bile duct and the duct of Wirsung have a common opening, has been discussed and found to be the cause in about 4.5 per cent of the cases.

Pancreatic infection by way of the blood stream is a possibility; it has developed in the course of some infectious diseases such as typhoid, influenza, furunculosis and parotitis. It is a well known fact that,

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especially in children, there is an involvement of the pancreas simulating acute pancreatitis that develops during the course of mumps.

Pancreatic infection by direct contiguity has also been discussed. Such conditions as perforation of a gastric or duodenal ulcer or carcinoma of the stomach with ulceration may cause pancreatic infection in a few cases. However, in going over the literature it is noted that within the last ten years only three cases have been reported in which a perforated ulcer was associated with acute pancreatitis. In a series of thirty autopsies performed at the Boston City Hospital in cases of acute pancreatitis, accompanying perforated gastric ulcer has been present in only one instance. The coexistence of disease of the gallbladder with acute pancreatitis has been prevalent in the experience of most authors, and especially in the German literature disease of the gallbladder and bile ducts holds the highest place by far among the associated etiologic factors. The marked difference between the pathology and pathogenesis of pancreatitis and those of all other acute infections is due to the fact that once the pancreatic tissue is sufficiently involved to result in activation of the trypsinogen the resulting trypsin proceeds to digest the organ itself and often neighboring tissues. This activation of trypsinogen may occur as a result of damage brought about by any of the aforementioned etiologic factors.

INCIDENCE

Age.—Table 1 demonstrates the incidence of acute pancreatitis according to age and points out that the highest incidence is between 30 and 60 years.

TABLE 1.—*Age by Decades*

Years	Cases
18 to 20	2
20 to 30	5
30 to 40	16
40 to 50	15
50 to 60	16
60 to 70	6
Total cases	60

The youngest patient in this series was 18 years of age, and the oldest, 70. The average age for males was 45.3 years and for females, 42.5 years. The average age for both sexes was 43.9 years.

Sex.—There is a preponderance of acute pancreatitis in the female sex, which is borne out in all tabulated series of cases of this disease. In this series there were thirty-five females and twenty-five males. The increased incidence of this disease in women is probably influenced somewhat by the frequency with which disease of the gallbladder occurs in this sex.

Color.—Of the sixty patients, four were colored, and all of these were of the female sex.

PHYSIOLOGY AND PHYSIOLOGIC CHEMISTRY

In experimentally produced pancreatitis in dogs there is an increase in the urea nitrogen and in the nonprotein nitrogen content of the blood in about two thirds of the cases. There is no change in the amount of chlorides. A slight increase in the carbon dioxide-combining power is found in a few cases. The change in nitrogenous elements closely simulates that in cases of experimental peritonitis, acute intestinal obstruction and dehydration. In all cases of pancreatic deficiency the following changes occur: Toxins form as a result of incomplete digestion of protein. There is an increase in bacterial activity in the intestines, which causes fermentation with the partly converted sugars. There is irritation of the intestines from the incompletely split fatty acids. In acute pancreatitis there is an increase in unsplit fat in the stools as well as an increased output of nitrogen in the urine not related to the intake of food. Glycosuria and an elevated blood sugar are sometimes found, but they are by no means constant.

There is an increase in diastase in the urine owing to the liberation of pancreatic ferments. The normal diastase in the urine varies from 8 to 32 units. In well defined cases of pancreatitis it is usually well over 100. In a recent case, not included in this series, there was a preoperative diastase reading of 128 and twenty-four hours following operation the value increased to 1,024 plus. Some types of disease of the gallbladder, peritonitis and severe glycosuria will increase the diastase content of the urine. This must be considered in interpreting this test. It is of interest to note that in a recent case of a ruptured infarct of the right lobe of the liver with profuse hemorrhage into the peritoneal cavity, producing a picture which closely resembled acute pancreatitis, the diastase reading was 128.

SIGNS AND SYMPTOMS

The signs and symptoms described are those which this series of patients presented on admission to the hospital and during their course of observation.

Pain.—The pain chiefly described has been that occurring in the epigastrium, at first steady and then intermittent, occurring in a rather rhythmic fashion. This pain has been described as being at its height sharp, stabbing and knifelike. The initial pain lasted from one to two hours, with relief for several hours, followed by an exacerbation of the same description. In most of the cases the pain did not radiate. In four cases it radiated to the tops of both shoulders. In two cases it radiated to the umbilicus; in two cases it radiated to both costal margins. In two cases it was referred to the small of the back. In no case did the pain radiate to the angle of the left scapula as is sometimes described. Pain was not relieved by morphine to the same extent that biliary colic

and renal colic are relieved, a classic feature of this disease. The onset of the pain in every case was sudden. In twenty-three cases there were recurrent attacks of epigastric pain dating anywhere from two weeks to fifteen years prior to the onset of the last attack. The previous attacks were all less severe than the one which brought the patient to the hospital.

Nausea and Vomiting.—In all cases there were associated nausea and vomiting following the pain. The first vomiting was continuous, with apparent evacuation of the contents of the stomach, following which there was retching at intervals; the patients described a regurgitation of bitter greenish material. In one case vomiting of frank blood was present.

Other Symptoms.—About 30 per cent of the patients gave a history of constipation. In no case was diarrhea present. Shortly after the onset of pain most of these patients described oncoming or gradually increasing distention of the abdomen with little relief obtained by enemas, a feature which makes one consider the possibility of intestinal obstruction.

All of these patients were either extremely well nourished or obese. On admission the patients were prostrated, five showing cyanosis and eight a slight icteric tint. On admission to the hospital the picture of shock was not present, and any shock which may have been associated, as is often described, must have been present at the onset. The pulse varied from 100 to 120 in rate and was of fair quality. The temperature varied between extremes of 96 F. in four cases and 103.5 in three, the remainder being between 98.6 and 101 F.; the average temperature was 99.2 F. The respiratory rate varied between 20 and 24. Examination of the head and neck revealed no significant signs. There were no associated findings in the chest or heart definitely related to acute pancreatitis, although moist râles were frequently present at the bases of both lungs at the time of admission. This can be explained by the close relationship of the pancreas to the diaphragm. Interference with diaphragmatic excursion results in a decrease in the expansion of the lungs and therefore hypostasis of the bases.

Signs.—The abdominal findings were the most significant symptoms at physical examination. Abdominal breathing was limited in practically all the cases and absent in many. Palpation revealed a characteristic soft distention below the umbilicus with an increasing mild spasm and rigidity above the umbilicus, but this was not by any means boardlike. The tenderness in the upper half of the abdomen was constant, definite and most severe in the midepigastrium. The next most common place was the right upper quadrant. In only one case was a mass palpable in the epigastrium. In no case was there ecchymosis in either flank. In five

cases, shifting dulness was noted. In many cases there was a rather diffuse tenderness over the lower, softly distended, portion of the abdomen, but it was not marked to any degree in any one place. In practically all the cases peristalsis was present, and in some it was definitely increased.

LABORATORY FINDINGS

The average white blood cell count was 17,000. Red cell counts were not made for every patient, but none of those which were made fell below 4,500,000; the highest was 5,054,000.

Sixteen patients showed a slight but definite trace of albumin in the urine. Four patients showed glycosuria. Acetone and diacetic acid were present in one case. The urine in all other cases was essentially normal.

SUMMARY OF CHARACTERISTICS

The characteristics of acute pancreatitis may be summarized as follows: prostration of the patient; severe, rhythmic, intermittent epigastric pain; recurrent retching and vomiting; softness and distention of the lower part of the abdomen; epigastric tenderness with mild spasm of the upper part of the abdomen; occasional slight jaundice, and occasional cyanosis.

The laboratory findings are an increased amount of diastase in the urine, a high red cell count, an increased white cell count and a comparatively low temperature. Glycosuria may or may not be present.

DIFFERENTIAL DIAGNOSES

In the literature extensive lists of other conditions are frequently considered under the heading of differential diagnosis. In the present series, the following diagnoses were seriously considered in one or more cases: perforated gastric or duodenal ulcer, acute cholecystitis, intestinal obstruction, subdiaphragmatic abscess, acute appendicitis, renal calculus, peritonitis, lobar pneumonia, diaphragmatic pleurisy, perinephritic abscess, coronary disease, ruptured ectopic pregnancy, pleurodynia and infarct of the liver.

SURGICAL PATHOLOGY

At exploration, in twenty-nine of the cases in this series there was free fluid in the peritoneal cavity. In twenty-six instances the fluid varied from serosanguineous to dark brown, the latter type representing old blood free in the peritoneal cavity. In three cases the fluid was of a clear straw-colored type. In eight cases fluid was found in the lesser peritoneal sac. In each of these the fluid consisted of old blood, pus and necrotic tissue of the sac. Organization of this material sometimes encapsulated the entire pancreas. Fatty necrosis was a common finding,

being present in forty cases. It was distributed in the great omentum, the adjoining viscera and the mesentery, over the pancreas and through the lesser sac. It was characterized by small islands made up of numerous small white areas averaging from 2 to 3 mm. in diameter. These islands of fatty necrosis alternated with normal areas of fat. In thirty-eight cases a hard, indurated pancreas was noted; it had swollen to from two to three times its normal size and was a somewhat reddish brown. In some of these cases, however, there were punctate hemorrhages under the capsule. A soft, necrotic pancreas was found in sixteen cases, and in six cases the pancreas was normal in size and consistency except for small areas of fatty necrosis. The small as well as the large intestines showed moderate distention.

TABLE 2.—*Type of Operation Performed*

Type of Operation	Cases	Deaths	Mortality, per Cent
Cholecystostomy plus drainage of pancreas	29	14	48
Cholecystectomy plus drainage of pancreas	7	4	57
Drainage through foramen of Winslow / Drainage of pelvis	9	5	55
Drainage of pancreas alone	15	9	60

TABLE 3.—*Length of Time from the Onset of Symptoms to Operation*

Interval Before Operation	Cases	Deaths	Mortality, per Cent
0 to 12 hours	17	12	64
12 to 24 hours	12	7	58
24 to 48 hours	15	6	40
2 to 6 days	9	2	22
7 to 12 days	4	2	50
12 days plus	3	3	100

Of the sixty patients, thirty-three (55 per cent), showed some type of associated disease of the gallbladder. Thirteen patients (21.7 per cent) showed a large, tense gallbladder. Fifteen (25 per cent) showed chronic cholecystitis plus stones, and five (8.3 per cent) showed macroscopically a pathologic picture of chronic cholecystitis without stones.

TREATMENT

In most clinics acute pancreatitis has been recognized as presenting a surgical emergency. Immediate operation has been advised by nearly all authors. The type of operation, however, varies in different clinics and in different cases in the same clinic. The indications vary with the different conditions found on exploration. In this series the operations performed are shown in table 2.

This table demonstrates that the lowest mortality rate occurred in cases in which the gallbladder and the pancreas were drained. The drainage of the pancreas in these cases was through the gastrohepatic omentum or the gastrocolic omentum. The drainage of the pancreas was induced by blunt dissection with the

finger so as to avoid extensive hemorrhage. Extensive splitting of the capsule and perforating pancreatic tissue leads to further liberation of pancreatic ferments and hemorrhage.

In table 3 the operations are classified according to the length of time from the onset of symptoms to the operation.

If all the cases were of equal severity this table would prove that the optimum time for operation is from two to six days after the onset. But possibly the patients who were operated on earlier had the more fulminating cases, and perhaps many of those who died would have died anyway. In spite of this, however, the difference in results between early and somewhat delayed operation indicates that delay should deliberately be tried in cases of all degrees of severity in a large series. There is little doubt that in a process as diffuse as this suggestive measures (nothing given by mouth, hypodermoclysis and administration of morphine) will probably allow nature to wall the process off to some extent and make the operation safer when it is performed.

Table 4 indicates the anesthetic used and the accompanying mortality.

TABLE 4.—*Mortality with Various Anesthetics*

Anesthetic	Cases	Deaths	Mortality, per Cent
Nitrous oxide, oxygen and ether	46	22	47
Spinal	10	6	60
Local	4	4	100

Anesthesia produced by nitrous oxide, oxygen and ether was accompanied by the lowest mortality rate. That ten operations were performed under spinal anesthesia is not sufficient proof of its value. The significance of local anesthesia cannot be evaluated from this series, because the four patients operated on were practically moribund from the beginning.

SUMMARY

The cases of sixty patients with acute pancreatitis treated surgically have been studied.

The incidence of disease of the gallbladder occurring with acute pancreatitis was 55 per cent.

The mortality rate was 53.3 per cent.

Cholecystostomy plus drainage of the pancreas through the gastrohepatic or gastrocolic omentum was the safest operation.

Nitrous oxide, oxygen and ether anesthesia was accompanied by the lowest mortality.

The fact that the mortality rate was the lowest in patients operated on from the second to the sixth day is of considerable interest. We realize that this series of cases is too small to warrant definite conclusions, but the results lead one to think that acute pancreatitis does not present as much of a surgical emergency as has been previously thought.

It is our plan in the future to be conservative in the treatment of acute pancreatitis and to delay operation to some time between the

second and sixth day, choosing the time when the patient's condition appears to have reached a maximum degree of recovery from the initial toxemia.

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A REVIEW OF UROLOGIC SURGERY

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(*Concluded from page 907*)

PROSTATE GLAND

Calculi.—Franceschi [27] stated that it is only recently that a clear distinction has been drawn between urethral calculi and true prostatic calculi formed and grown primarily within the substance of the prostate. Since 1927 he has found only 16 cases of the latter in the literature. True endoprostatic caculi may be either autochthonous (endogenous) or migrating (exogenous), the former being the more rare. Endoprostatic calculi migrating from the urethra into the prostate, of which a case is here reported, are generally small and numerous but may occasionally be large and single, as in the present case, in which the form of the calculus confirmed its deep endoprostatic situation by the faithfulness with which its arborization repeated the acinous structure of the organ within which it had developed.

The mode of exclusion of these calculi from the urethra may be conceived as the formation of a parenchymatous or interstitial reaction, with organization of granulation tissue, or there may be a purely mechanical factor of inclusion following fibro-adenomatosis, especially in men with a tendency to prostatism. The commonest type of stone formation is uric acid lithiasis, and the type of infection most frequently associated therewith is that which results from the enterococcus. The p_H seems to be more acid in this condition, with the presence of crystals of sodium urate or of free uric acid. These concretions are almost symptomless and are usually discovered at the time of prostatectomy. They

27. Franceschi, Eugenio: Contributo allo studio della calcolosi prostatica vera, Arch. ital di urol. **11**:366 (June) 1934.

may escape detection in the roentgenogram, since uratic calculi have a composition similar to that of the soft parts of the body and are among those least visible roentgenographically, even on the best films, while calculi of pure uric acid may be invisible, especially if they lie deep within a parenchymal organ.

Endoprostatic calculi may be masked completely by prostatism until some congestive or infective factor favors their mobilization. In this stage they present the characteristic and marked sign of producing a grating sensation on introduction of the sound, a sign which may be regarded as pathognomonic. In Franceschi's case in a man 79 years of age, the remarkable feature was the fact that there had been no signs of prostatism until a few weeks before observation, when an attack of retention occurred, for which the patient treated himself with a retention catheter which he was wearing when he came in for treatment. It is probable that the irritation produced by the catheter was responsible for the mobilization of the calculus, which was found at operation and was removed by the suprapubic route. Franceschi regarded this approach as the safest, and he found valuable aid in incision of the neck of the bladder. This route gives the best guarantee of success with prompt and secure drainage, besides resting the bladder without exposing the patient to the risks of perineotomy, which may lead to the formation of fistulas and to recurrence, particularly if periprostatitis and rectal adhesions are present. When chronic prostatitis exists, a suprapubic prostatectomy is often the best mode of treatment.

[COMPILER'S NOTE.—In the surgical management of prostatic calculi, it appears that the perineal route of approach is surgically and anatomically the most convenient, since it is easier to expose the prostate gland and remove the calculi under direct vision without opening the bladder, thereby simplifying the procedure. Those patients who are subjected to a suprapubic operation for drainage of a prostatic abscess or for the removal of prostatic calculi are required to stay in the hospital much longer than those on whom a perineal operation is carried out for one of the same conditions. It has also been shown that the surgical shock is greatly diminished in the perineal operation and that the drainage from below is always more satisfactory, even when prostatectomy is to be done. It is evident, therefore, that in cases of prostatic calculi the procedure of choice should always be by the perineal route rather than by the suprapubic route.]

Hamer and Dykhuizen [28] stated that calculi found in the prostate fall into one of two main groups: the endogenous, which are formed in the prostate gland and, at least at their inception, never come in contact with the urinary constituents, and the exogenous, which are formed

28. Hamer, H. G., and Dykhuizen, T. A.: Prostatic Calculi, Am. J. Surg. **24**: 119 (April) 1934.

higher up in the urinary tract and are arrested in the prostatic urethra where they increase in size. The latter calculi cannot be regarded as true prostatic calculi since they originate outside of the prostate gland and are composed of urinary salts. These can be distinguished from true prostatic calculi which have eroded through the prostate gland and have acquired a secondary coating of urinary concretions by chemical examination of their nuclei. A true prostatic calculus has an albuminoid nucleus, whereas an exogenous calculus has a nucleus composed of uric acid, urates or oxalates. The true prostatic calculi are probably formed by deposits of calcareous material on the corpora amylacea, which are frequently met in sections of apparently normal glands. Prostatic calculi are found chiefly in adults, although in the series of 305 cases reviewed by Thomas and Robert, 4 boys aged 10 years had prostatic stones. These investigators found that two thirds of the patients were between 40 and 60 years of age, the greatest number being between the ages of 50 and 60. Hamer and Dykhuizen stated that several pathologic conditions are found associated with prostatic stones. Invariably there is a low grade of prostatitis; urethral strictures are relatively frequent; calculi in other parts of the urinary tract are frequently demonstrated; carcinoma of the prostate seems to be a rare accompanying lesion. True prostatic calculi are almost always multiple. Joly believed that the cases in which a single stone has been removed are examples of urinary stones that have become lodged in the prostate. Usually the smaller stones occur in such numbers and are so small that it is impossible to count them. There are recorded cases in which more than a thousand stones have been removed. The smaller stones are usually round and have no facets; they are dark brown and can often be cut with a knife. They are often scattered throughout the prostate gland and extend down the ducts and into the acini. These give a characteristic dotted appearance on the roentgenogram. The larger stones usually occur in pouches formed by the destruction of the glandular walls. Frequently these stones are faceted where they touch one another. The most common arrangement, as viewed on the roentgenogram, is a mass of stones in each lateral lobe connected by an isthmus. The distribution is not always symmetrical. Chemical analysis of the stones reveals that they are composed of an organic and an inorganic element. The organic material, which forms the nucleus, is of an albuminoid nature but is apparently not a true protein. The inorganic salts are calcium phosphate, potassium phosphate, magnesium phosphate, calcium oxalate and calcium carbonate. The changes in the prostate vary according to whether there has been suppuration and whether the stones have attained sufficient size to ulcerate through the gland. The gland is invariably enlarged but is rarely over twice its normal size. Its surface is firm and is usually regular, but at times it is nodular and hard. If the stones are large, the condition can be distinguished from

carcinoma of the prostate by the roentgenogram. Usually the border of the prostate is well defined in cases of calculi in contrast to the irregularity of the border in cases of carcinoma, and this aids in differentiating the two conditions by rectal examination. The roentgenogram is most important in making a diagnosis of prostatic calculi, but one should bear in mind the possibility of phleboliths in the prostatic plexus. Often, however, a presumptive diagnosis and less often a positive diagnosis can be made by other means. Sometimes prostatic stones are first suspected by the grating which they impart to an instrument passed into the urethra. Hamer and Dykhuizen stated that the treatment of prostatic calculi often will depend on the other conditions which are present. The frequency with which prostatic hypertrophy accompanies prostatic calculi makes the treatment of the former condition of primary importance, and the stones are of secondary interest. When the stones were small and very numerous the prostate was enucleated through the suprapubic route, and the resulting cavity was thoroughly explored and sponged. A surprising number of stones are recovered clinging to the dry gauze sponge, even after a thorough digital examination fails to detect them. Many operators prefer the perineal route for the removal of larger stones. The presence of small prostatic calculi does not contraindicate electrical resection or interfere appreciably with this procedure. On the contrary, it was found to be a satisfactory method of removing a subcervical nest of calculi in 1 case.

Resection.—Transurethral manipulations and operations have substantially transformed urologic practice. Conservative management of lesions of the upper part of the urinary tract, such as relief of infection, stasis, technical expulsion of stone, relief of certain hematurias and correction of ureteral drainage defects, proclaims its effectiveness. It has even a greater field in cases of lesions of the bladder and of the lower part of the urinary tract, and its application in recent years for all types of obstruction of the neck of the bladder has revolutionized prostatic surgery.

Caulk [29] has performed 900 transurethral prostatic resections with his cautery punch, with an operative mortality of 1 per cent. He emphasized the necessity for repeated operations in cases of the larger prostatic hyperplasias and stressed the marked retrogression and shrinkage in the remaining portion of the gland following partial resection.

He emphasized the advantages of the punch operation with the cautery current over the more commonly employed electroresection with the high frequency current. To the destructive effects of the latter he

29. Caulk, J. R.: Transurethral Surgery, Surg., Gynec. & Obst. **58**:341 (Feb.) 1934.

attributes most of the hemorrhage, infection, sepsis and toxic absorption which not infrequently follow electroresection.

To study the effect on tissues and the heat-penetrating properties of various electric currents, extensive and elaborate experimental studies on both animals and human beings were undertaken. A standard thermocouple galvanometer was used to record the temperature of the tissue. The deductions reached were:

1. High frequency currents generate heat in the tissues at points distantly removed from the actual site of burning, often in a degree exceeding the thermal death point of the tissue cells,

2. The heat generated in the tissues by the cautery current never penetrates to such depths.

3. The coagulation currents producing pronounced superficial necrosis result in much less intense heat in the tissue than the cutting currents of higher tension values.

4. The cumulative effects of heat generated in the tissue may be partially combated by restriction of the duration of repeated applications of the high frequency current so as not to retard unduly the normal flow of blood through the prostate gland. This has been estimated to be 0.68 Gm. of blood per cubic centimeter of tissue per minute.

He concluded that the incidence of secondary hemorrhage and sepsis following resection with the high frequency current can be attributed to the erosive effect of late sloughing on the walls of the blood vessels as a result of the penetrating effects of the heat of the current. This cellular destructive effect is not present with the cautery method of resection, in which there is simply a superficial reaction.

It is of the utmost importance during the performance of resection with the high frequency current that currents of minimal tension value be employed, that the cutting action be performed expeditiously, that repeated resections at one point be avoided if possible, and that surface coagulation be utilized for the sealing of bleeding points. For these reasons, extensive and repeated resections necessitating a large number of applications of the current are to be condemned, since the accumulation of heat and subsequent destruction of tissue in the outer surfaces of the gland may be productive of late sloughing and erosion, with the development of urinary extravasation, the formation of a fistula and urinary incontinence.

A clinical study of the relative merits of the two methods was made through a questionnaire answered by 244 surgeons who had performed 15,488 transurethral operations, of which 7,415 were done by the punch method and 8,073 by electroresection. Analysis of the answers showed that the incidence of postoperative hemorrhage following electroresection exceeded that following the cautery method in the ratio of 2:1, and the

same proportion also applies to the necessity for cystotomy in its control. Urinary sepsis also occurred more frequently, the ratio being 2.5 : 1, whereas the incidence of other complications as a postoperative complication with electroresection, e. g., urinary incontinence, fistulas, prostatic abscess and rupture of the bladder, was also greater than with the cautery method; they occurred 39 times with the former and 9 times with the latter. It is of interest to note that the development of recto-urethral fistula complicated the course following electroresection 5 times, whereas there is no record of this with the cautery operation.

Caulk concluded that the experimental and statistical study demonstrates the greater value of the cautery method of transurethral resection as compared to electroresection. He described a modification of his punch instrument which provides telescopic visualization of the operative field.

Garshwiler, Weyerbacher and Balch [30] stated that transurethral prostatic resection is a distinct advance in the management of obstruction of the neck of the bladder but that it should be used in selected cases. It is conceded that median fibrotic bars, carcinoma of the prostate, hypertrophy of the middle lobes and less extensive hypertrophy of the lateral lobes are ideal conditions in which to use resection. In cases of more extensive hypertrophy, especially of the lateral lobe, prostatectomy should be used. They stated that functional results have been very gratifying in their cases, with the exception of a few cases of enormous hypertrophy of the lateral lobes. Postoperative morbidity and complications have been conspicuously few and very mild. The authors have noted many more complications during preparation with catheter drainage than after resection. Their mortality has been 2 per cent.

From the standpoint of end-results, Goldstein and Herschman [31] stated that they have not met the same success that they have had in their cases in which prostatectomy was performed. There was a direct operative mortality of 10 per cent. Five of the 6 deaths occurred in cases in which the patients presented a poor surgical risk. The authors were able to operate on 18 patients who in all probability would not have been able to stand the surgical shock caused by an open major operation. In other words, 13, or 72.2 per cent, of these patients at the time of the report were living and comfortable without "leading a catheter life." Pyelonephritis is the complication most frequently encountered and causes a great deal of concern when present. The

30. Garshwiler, W. P.; Weyerbacher, A. F., and Balch, J. F.: Transurethral Prostatic Resection: Study of Functional Results and Morbidity Following This Procedure, Urol. & Cutan. Rev. **38**:413 (June) 1934.

31. Goldstein, A. E., and Herschman, M. J.: End Results in Prostatic Resection, Urol. & Cutan. Rev. **38**:410 (June) 1934.

authors' best results were obtained in cases of contracture of the vesical orifice and median bars.

Folsom and Alexander [32] stated that it was their opinion that prostatic resection, in the hands of competent operators, is destined practically to supplant the older types of surgical procedure. This view is based on their experience in 225 cases in which resection was performed. At the same time they had performed prostatectomy in only 3 cases, which means that they had been able to relieve 98 per cent of their patients during the past two and one-half years with this procedure.

Day [33] stated that prostatic resection, as developed during the past three years, has enormously widened the field of transurethral operations. Because it is spectacular and in the beginning seemed so simple and harmless, it resulted in widespread publicity even among the laity. Therefore the laity demanded it, even those persons with incipient prostatic hyperplasia who would have been better off without operation for the time being. Day expressed the belief that great gains have resulted from resection selectively employed and that its use should be encouraged and not abused. He stated that from 50 to 65 per cent of persons with adenomatous prostates fare better after prostatectomy than after resection and that the mortality after prostatic enucleation in comparable circumstances is certainly no greater and probably less. The postresection morbidity and the deaths occurring in the succeeding six months stamp indiscriminate resection as unsound practice.

Sargent [34] stated that without any convincing exceptions each of the pioneers in resection has reported a substantial mortality in his early cases, whereas, with judgment and skill obtained by experience mortality practically disappeared. The very unanimity of that experience points to two conclusions. One is that resection without the benefit of adequate training under some one who is experienced is an extremely dangerous procedure. The other is that with experience resection comes to be both simple and safe. Sepsis is the outstanding danger. Here again is demonstrated the old observation that it is practically impossible to escape a certain amount of infection in operations on the bladder and that when the urinary tract is thus infected it demands drainage that is free, uninterrupted and adequately prolonged.

Weltman and Plaggemeyer [35] found that as one gains experience with the resectoscope, its field of usefulness greatly broadens. The

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32. Folsom, A. I., and Alexander, J. C.: Report of Two Hundred and Twenty-five Prostatic Resections, Urol. & Cutan. Rev. **38**:400 (June) 1934.

33. Day, R. V.: Prostatic Resection: Its Comparative Evaluation, Urol. & Cutan. Rev. **38**:397 (June) 1934.

34. Sargent, J. C.: Resection of the Prostate: An Evaluation, Urol. & Cutan. Rev. **38**:394 (June) 1934.

35. Weltman, C. C., and Plaggemeyer, H. W.: Two Years' Experience with the Resectoscope, Urol. & Cutan. Rev. **38**:392 (June) 1934.

operator with sufficient experience and ability will be able to remove successfully practically all types of prostates transurethrally. The procedure is, and always will be, a difficult and laborious task, so filled with potential pitfalls that one must be constantly on guard. It is easy for the patient but difficult and tricky for the operator. Weltman and Plaggemeyer stated the belief that in the future, owing to the lessened risk to the patient, men with urinary obstruction will seek resection early before large amounts of residual urine accumulate and before severe infection and renal damage occur. The results will be much better.. They stressed that in spite of the most meticulous care in preoperative and postoperative handling the one outstanding thing that the expert resectionist has to guard against is infection.

Mathé [36] stated that at the present time the indications for transurethral resection are being defined. Enthusiastic urologists who have become expert in endoscopy employ the transurethral method for the relief of nearly all types of prostatic hypertrophy that come under their care. The following percentages indicate how widely some urologists are applying the procedure: Ballenger, Elder and McDonald, 95 per cent; at the Mayo Clinic, 98 per cent; Engel, 85 per cent, and Alcock, Kretschmer and Caulk, nearly 100 per cent. These surgeons use this method in cases of moderate hypertrophy, including hypertrophy of the median lobe with intravesical encroachment, bilateral lobular involvement and trilobular hypertrophy. Their writings indicate that they feel that open prostatectomy, a well established surgical procedure, is about to be discarded in favor of resection. Another large group of more conservative men, Lowsley, Collings and de Shivers, feel that this procedure should not be employed in the vast majority of cases of prostatic hypertrophy; they limit its use to cases of hypertrophy of the subcervical group of glands, cases of moderate bilobular and trilobular adenomas and cases of fibrosis connected with the collar type of hypertrophy or atrophy of the prostate. A third group feel that their experience with resection justifies its application in an increasingly large number of cases, from 80 to 85 per cent of all cases of prostatism, but they have pointed out that it is insufficient to give permanent relief in cases of an extremely vascular gland and no relief whatever in those cases in which it is mechanically impossible to pass the resectoscope or to perform resection of sufficient tissue without danger of perforating the prostatic capsule or the wall of the bladder. Mathé stated that with the improvement of technic on the part of the resectionist the percentage of cases in which resection can be successfully performed increases in direct proportion to the skill acquired, with

36. Mathé, C. P.: Further Observations in the Treatment of Prostatic Hypertrophy by Transurethral Resection, Urol. & Cutan. Rev. **38**:381 (June) 1934.

the result that this method is unsuccessful in only from 5 to 15 per cent of cases of all types of prostatic disease. The contraindications to resection are: (1) inability to pass the resectoscope, which may result from congenital and acquired stricture of the urethra and vesical neck, and distortion of the prostatic urethra resulting from bizarre forms acquired by the hypertrophied prostate; (2) spongy hypertrophy in which instrumentation and resection cause extensive hemorrhage; (3) massive hypertrophy of the prostate; (4) hypertrophy complicated by diverticula and huge stones in the bladder; (5) contracted bladder (capacity under 150 cc.), and (6) cystotomy.

Mathé concluded that resection deserves a firm place among the operative procedures on the prostate gland. It has come to stay and its indications have been rather well defined. When properly performed, it will give satisfactory and lasting results in cases in which the patients are suffering from the collar type of fibrotic hypertrophy, atrophic sclerosis and moderate hypertrophy of the median and lateral lobes. It also affords palliative relief to the patient who presents a poor risk and who has massive hypertrophy or carcinoma of the prostate, in which case an open operation is contraindicated. Mathé said that it does not supplant prostatectomy, which should be employed in cases in which there are massive hypertrophy and spongy bleeding. Prostatectomy should likewise be employed in all cases in which instrumentation is hazardous by reason of a severe reaction on the part of the patient or because of urethral stricture, pathologic deformity of the anterior and posterior urethra and marked contraction of the bladder. Open operation is also indicated in cases in which there are complicating diverticula and huge stones of the bladder and in those in which it has been necessary to perform cystotomy. Transurethral resection of the prostate is a highly technical procedure that is difficult to learn and can be performed skilfully only after the development of proper technic. In skilled hands, uniformly good results have been obtained, and the mortality has proved to be lower than with prostatectomy.

Ballenger, Elder and McDonald,[37] who have had twenty-five years of experience with prostatectomy and who have employed transurethral resection 290 times on 227 patients, have compared their results with each of these procedures and have found that the comparison strongly favored transurethral resection. Four of the patients who were subjected to resection died: 2 from heart failure, 1 from uremia and 1 from pneumonia. Considering the greatly enfeebled condition of many of

37. Ballenger, E. G.; Elder, O. F., and McDonald, H. P.: Analysis of the Results of Two Hundred and Ninety Transurethral Prostatic Resections, Urol. & Cutan. Rev. **38**:407 (June) 1934.

the patients who were subjected to resection, the authors felt that had they been subjected to prostatectomy, either in one or in two stages, the mortality probably would have been five times greater. In fact, many of the patients would have been regarded as too feeble to withstand prostatectomy. This group includes all of the operable patients who had prostatic obstruction, except 2 for whom prostatectomy was employed because of the large size of the hypertrophied mass. The average age of the patients was 64 years; the oldest patient was 86 years of age. The time required in the hospital after the resection for 90 per cent of the patients was five days. Hemorrhage is probably the most important complicating factor in resection. Patients vary greatly as to the amount of bleeding which occurs. Extra care should be taken in checking oozing and bleeding in cases in which there has been a fall in blood pressure, even though considerable time may be required in the operating room for the caffeine, sodium benzoate and other remedies to raise the blood pressure. Late bleeding was not of infrequent occurrence, especially during the second and third weeks after operation. This nearly always responded to rest, free intake of fluids and medication. In no case were hemostatic bags employed, nor was suprapubic cystotomy required or done for the control of bleeding at the time of resection or later. As a rule the bleeding varied with the size of the gland, although many patients who had hypertrophy of considerable size bled very little; this was in cases in which the tissue cut like potato. Bleeding should always be expected; at least, all precautions should be taken to have every part of the equipment in thorough working order and the patient adequately anesthetized so that he is quiet and does not strain or try to move. Low spinal anesthesia is the method of choice. It is kept low by using a solution containing procaine and strychnine, which is lighter than the spinal fluid, and by tilting the head of the table downward before injecting the solution. The table is kept level while the needle is being inserted. When the needle is properly placed, the head is lowered, and not until then is the injection made. The sexual function, as a rule, is not impaired by prostatic resection; sometimes it is improved; at other times it remains the same as before the operation. In this series none of the patients had incontinence, and Ballenger, Elder and McDonald stated that they had no fear of it because they took such extreme care with all cuts near the verumontanum. The good results already obtained, however, by those doing a large number of resections, the low mortality, the small amount of pain incident to the procedure and the short time needed for postoperative hospitalization have already proved that the procedure is a definite improvement over prostatectomy.

Carcinoma.—Stirling [38] stated that the treatment of prostatic malignant conditions consists in the radical procedures of prostatectomy with radium implantation and roentgen irradiation of the prostatic region in cases in which the growth is confined to the capsule and in which urinary obstruction is present. If there is no obstruction, radium implantation and roentgen irradiation may be used. When the malignant growth has extended beyond the prostatic capsule, as had happened in the majority of cases when diagnosed, radical surgical measures rarely effected a cure, and the procedure to be followed is either punching out or resecting the obstruction; this should be repeated as needed to insure the patency of the urethra. Radium and roentgen therapy should be used to stop pain and bleeding. These agents will often retard the growth and cause a marked improvement in the patient's condition. Before any operative procedure is undertaken for carcinoma of the prostate, a preliminary roentgenologic study should be made, including cysto-urethrograms to determine the type of tumor, its location and extent and whether metastasis has supervened.

Sarcoma.—Gilbert [39] reported 2 cases of sarcoma of the prostate gland which affected youths and reviewed the recent literature to determine the value of irradiation in the control of this disease. Both cases demonstrated unusually difficult diagnostic problems and were regarded as infectious. Thus, emphasis was laid by Gilbert on the differentiation of sarcoma and prostatic abscess. In 75 per cent of the cases the growth occurs before the generally accepted age for carcinoma of 40 years, and in about 80 per cent of cases it occurs before the usual age for prostatic adenoma. The highest age incidence is between 1 and 10 years; about 30 per cent of the patients are between these ages. Pain may be located deep in the pelvis and may be constant; it may be related only to the intestine or to the urinary tract. It usually extends to the sacral region and posteriorly down the legs. Hematuria is a variable and unreliable symptom. It depends on ulceration of the primary tumor into the bladder or posterior urethra and is rare among children as the rapidly growing mass frequently produces obstruction much earlier in the course of the disease. The preoperative diagnosis of sarcoma of the prostate is rarely made, possibly because it is known to be rare and is seldom considered. The onset is usually insidious, and the symptoms are not uniform. The soft doughy feel of the tumor commonly leads to a diagnosis of simple cyst, echinococcus cyst, hypertrophy and occasionally carcinoma. Widespread metastasis occurs early, and thorough

38. Stirling, W. C.: Treatment of Prostatic Cancer, South. M. J. **27**:590 (July) 1934.

39. Gilbert, J. B.: Sarcoma of the Prostate: Report of Two Cases, J. Urol. **32**:63 (July) 1934.

roentgenographic studies of the chest and bony structure (skeleton) should be made as a routine measure as they are when carcinoma is suspected. The incidence of metastasis to the lungs as well as to the bones was 33 per cent in Smith and Torgerson's series of 34 cases. In other cases the tumor has filled the whole pelvis, extending superiorly to the umbilicus. The contour is usually regular but not always smooth and is of a peculiar firm consistency, which is described as "boggy." Its consistency resembles that of a gland which has been chronically infected. It follows that the more rapid the growth of the tumor in younger patients, the less dense is its consistency. Gilbert stated that a variety of surgical procedures have failed to control the disease adequately. He believed that surgical intervention was indicated only to relieve obstruction and in the treatment of complications. Complete prostatectomy is seldom possible as the tumor is only rarely found to be limited within the capsule. Irradiation, both theoretically and clinically, offers a greater chance to control this disease. Adequate intensive irradiation by means of gold radon implants and high voltage roentgen therapy, preferably by the Coutard technic, is advocated primarily in all cases. Clinical control in between two and six years has been obtained in cases in which the patients were more than 40 years of age. In the case of young patients, however, the average extension of life has been six months. A review of results in the recent literature indicated the superiority of irradiation over any type of surgical procedure. This disease, when treated by surgical methods, has been uniformly fatal. Bettoni reported that after twenty radical operations 75 per cent of the patients had recurrences in two or three months. Smith and Torgerson record that 14 of a total of 84 patients lived two and one-half months or less after the onset of symptoms. They concluded that the round cell type of tumor is the most malignant; in 30 cases recorded, the average duration of life was one hundred and forty-four days. The percentage of other types of tumors was so small that their relative degree of malignancy could not be correctly estimated. However, it may be assumed that the spindle cell type, along with the other less cellular tumors, is less malignant.

URETHRA

Trauma.—Ormond and Cothron [40] described a case of fracture of the pelvis with complete severance of the urethra just anterior to the prostate gland. Suprapubic cystostomy and insertion of a Pilcher bag, after the passage of a sound through the urethra and subvesical space

40. Ormond, J. K., and Cothron, R. M.: A Simple Method of Treating Complete Severance of the Urethra Complicating Fracture of the Pelvis, J. A. M. A. **102**:2180 (June 30) 1934.

with the assistance of a finger in the opened vesical neck, served to approximate the torn ends of the urethra and to obliterate the void between the segments. The bag was left distended for two weeks and was then withdrawn; an indwelling catheter and suprapubic drain were left in for several days longer. The suprapubic wound healed quickly, and normal urination was effected in three days. The authors expressed the opinion that this procedure is rapid and avoids perineal section with its possible danger to future sexual function and almost unavoidable urethral stricture.

TESTES

Undescended Testes.—Aberle and Jenkins [41] stated that the anterior pituitary-like principle from the urine of pregnant women caused the testes to descend in 2 of 4 boys who received injections. In only 1 instance was the descent complete. The substance caused hypertrophy of the scrotum and testes and in 1 instance growth of the penis. In immature monkeys which had been subjected to unilateral orchidectomy, this hormone caused complete descent of the testes in 1 animal and partial descent in 4. In these 4 animals the fascia surrounding the vas deferens and spermatic vessel was too short to allow the testes to reach the lower part of the scrotum. The failure of the treatment may have been the result of an incorrect amount of hormone, of age, of nutrition or of some factor related to the activity of the other endocrine glands. In the case of man, possible external mechanical obstruction and developmental irregularities must be considered. Microscopic examination of the testes of the monkeys which had received injections of the hormone revealed marked tubular enlargement and a corresponding increase in interstitial material but no mature sperm. Identical amounts of the anterior pituitary-like factor caused various degrees of hypertrophy in the prostate, seminal vesicles and testes of immature monkeys. The total dosage of the principle administered is not in direct proportion to the distance that the testes descend either in man or in monkeys.

Engle first described the experimental production of descent of the testes in immature monkeys by the injection of hormones of the anterior pituitary body or of substances obtained from the urine of pregnant women. Cohn [42] stated that the incidence of undescended testis among army recruits is reported as varying from 2 to 5 per thousand applicants. The right side is more frequently affected, and the condition is bilateral in about 25 per cent of cases. Engle gave

41. Aberle, S. B. D., and Jenkins, R. H.: Undescended Testes in Man and Rhesus Monkeys Treated with Anterior Pituitary-Like Principle from Urine of Pregnancy, J. A. M. A. **103**:314 (Aug. 4) 1934.

42. Cohn, Samuel: Anterior Pituitary-Like Principle in the Treatment of Maldescent of the Testicle, J. A. M. A. **103**:103 (July 14) 1934.

a brief and sketchy résumé of certain published results which suggest that the operative treatment for maldescent of the testes is unsatisfactory in from 20 to 68 per cent of cases.

Lower and Johnson, working with normal adult rats, found that the injection of the gonad-stimulating hormone of the anterior pituitary body resulted in stimulation of the testes, as well as of the prostate gland and seminal vesicles. Other similar experiments indicate that although the testes did not appreciably increase in weight, the accessory organs increased markedly under the influence of the gonad-stimulating hormone, attaining the size characteristic of these organs in young adults. Evans repeated these experiments, but he said in addition that the testes themselves actually decreased in weight and seemed to be damaged by the treatment. Other work showed that anterior pituitary-like substance accelerated spermatogenesis and increased the size of the testes in immature rats.

Engle's work with monkeys formed the stimulus for Cohn's application of this principle to human beings. Six cases are reported in which 100 rat units of a commercial preparation (a purified form of the anterior pituitary-like sex hormone from the urine of pregnant women) was given subcutaneously three times weekly for ten injections. Cohn concluded from this small group of patients that this preparation is apparently effective in causing descent of undescended testes when there is no anatomic malformation to act as a mechanical obstruction. When an obstruction exists, a partial descent will occur, but operation will be required to complete the process. In surgical cases, the anterior pituitary-like principle is a valuable adjunct in the production of a successful outcome. In 4 otherwise normal children Cohn produced complete descent of one testis in 3 and only partial descent in the fourth, who, he stated, showed evidence of mechanical obstruction and will require operation.

To overcome the disadvantages of the Torek operation and to provide greater postoperative comfort and a shorter period of disability from the operation, Wolfson and Turkeltaub [43] have modified the technic as follows: Over the inguinal canal, hockey stick incisions, beginning at the pubic area, are made through the skin and the aponeurosis of the external oblique muscle. The broken lines are directed outward and upward. The external abdominal ring is split through at the middle of the intercolumnar fibers. The blades of the aponeurosis are separated widely to permit more mobility and better relaxation of the arched fibers of the internal oblique and transverse muscles. The gubernaculum testis should be identified and traced to

43. Wolfson, W. L., and Turkeltaub, S. M.: A Modified Torek Operation, Am. J. Surg. **25**:494 (Sept.) 1934.

the lower attachment, which is then doubly clamped low down, cut and tied at both ends. The testis is palpated, viewed and appraised. Usually, it is covered with a veil of cremasteric muscle, from which it must be lifted. The testis and the spermatic cord are now gradually withdrawn from the inguinal canal. A finger dissection will mobilize this structure from its bindings of cremasteric muscle, adhesions and transverse fascia by starting posteriorly and working deep and high up into the retroperitoneal space. The vaginal process or peritoneal tube is freed from the vas deferens and spermatic vessels of the cord. The cord may be lengthened by separating all peritoneal remnants and adventitious tissue between the vas deferens and the spermatic vessels as far down as the testis and epididymis. The new bed for the testis is prepared by forcing a finger to the bottom of the scrotum. The base of the scrotum is next grasped with two Allis forceps 2 cm. apart. A transverse slit is made through the skin and dartos between the clamps. Another incision, parallel to, but lower than, the first and of equal length, is made on the inner and upper part of the thigh, facing the scrotum. The structures of the cord are correctly alined. The length and the position of the testis in the scrotum are noted. If satisfactory, a clamp is passed through the scrotal incision to grasp and withdraw the free end of the gubernaculum testis through the scrotal slit. The testis is carried to the bottom of the scrotum. A union of the upper skin flap in the thigh to the posterior skin flap of the scrotum is then established with interrupted sutures. The gubernaculum testis is sutured to the newly formed posterior skin suture line with interrupted sutures of fine silk. The anterior and complete closure of the skin wound is then effected with silk sutures, which also incorporate the gubernaculum testis to this union. The inguinal canal and structure are reformed and reunited with sutures of no. 1 catgut. The spermatic cord should not be displaced. Two weeks after the orchiopexy the patient resumes his physical activities. Two months later the scrotum is detached from the thigh by an incision around the circumference of the scar and through the gubernaculum testis. A few interrupted sutures close the wounds of the two surfaces. This operation has been performed with satisfactory results in 45 cases of maldescended testis.

Tumor.—Salmon and Contiadès [44] reported a case of fibroma of Morgagni's hydatid in a man, aged 55. The small, solid, pediculate tumor, about the size of a hazelnut, was inserted at the anterosuperior pole of the right testis, where it had undergone fibrous degeneration with torsion. Histologically, it was a pure fibroma which did not

44. Salmon, Michel, and Contiadès, X. J.: Fibrome de l'hydatide testiculaire de Morgagni, J. d'urol. **37**:412 (May) 1934.

contain any muscle fibers but did contain an abundant formation of collagenic tissue which was in a state of inflammation. A search of the literature revealed no previous instance of any tumor that had been recognized as a pediculate fibroma of Morgagni's hydatid, but in several cases certain facts were reported which gave rather clear evidence of such origin. Glass reported a case similar to this in which on opening the tunica vaginalis for a slight effusion, a small pediculate, cellular fibroma, 5 cm. in length, was found resting on the albuginea. The structure of this tumor was beyond question the same as that of the one reported, but its topography is left in doubt since there was no mention of the insertion of the pedicle. It appears entirely possible, however, that it was a fibroma of the hydatid of Morgagni. In the case which was reported by Lavenant, a white foreign body, the size of a bean, was observed within the tunica vaginalis, which was causing severe attacks of pain, while the testis and epididymis were normal. Lavenant suggested the hypothesis that the structure was derived from some such embryonal débris as the hydatid, Geraldes' body or the vas aberrans of Haller, which was in a state of chronic inflammation. Before the formation became a floating body it seemed to have possessed a pedicle, of which the hilus that was discovered was the last remaining trace. In the case here presented the operative findings revealed the insertion of the fibroma into the subepididymal furrow in the place of the normal hydatid, suggesting that it was a fibroma of the latter. The case is no doubt exceptional since the only previous observations at all comparable with it have been the result of purely anatomic findings and often have been incomplete and disputable. Clinically, the diagnosis may be suspected if the tumor is not too large. The most important points to observe are the connections of the tumor and its topography and mobility. Its opacity can be demonstrated by the absence of transparency when transillumination is carried out with a focus of light of small size and in a dark chamber. If the conception of a solid tumor situated under the head of the epididymis is then reached, it is justifiable to think of the possibility of an origin in Morgagni's hydatid, even though the greater probability is that of a polyp of the tunica vaginalis. The proper treatment of such a pediculate tumor consists of its extirpation, together with resection of the tunica vaginalis if there is any considerable serous effusion. It is possible that cases of this kind are, after all, not so rare as they seem, owing to the fact that at their outset the tumors exhibit no symptoms of any importance.

Henline [45] stated that the diagnosis of malignant tumors of the testis may be definitely made by determination of the presence of the

45. Henline, R. B.: The Differential Diagnosis and Treatment of Tumors of the Testicle with Report of a Case of Bilateral Fibroma of the Testes, J. Urol. **32**:177 (Aug.) 1934.

anterior hypophyseal sex hormone in the urine by the Zondek method. The pathologic type of tumor may be determined before operation by the quantitative estimation of the excretion of this hormone. Local recurrences or metastasis may now be determined, even before clinical detection of the lesion is possible, by the reappearance or increase in the amount of the hormone excreted. The effect of irradiation of a testicular tumor on the excretion of this principle determines its radiosensitivity; thus, proper treatment may be outlined early in the course of the disease. Castration in the adult male may produce little or no change in his secondary sex characteristics.

SEMINAL VESICLE

Carcinoma.—Pelagatti [46] has added the report of an additional case to the 7 cases of undoubted malignant growth of seminal vesicular origin which he found reported in the literature. The only symptom experienced by the patient, a man aged 30, was obstinate constipation. Abdominal palpation revealed a nodule the size of a walnut on the left side and another, the size of an orange, a little nearer the left colic angle, while rectal palpation at the level of the prostate revealed an enormous mass which filled the entire small pelvis. The neoplasm, which was judged to be a tumor of the prostate, was considered inoperable, and the patient was sent home. Nine months later he was seen again, and at this time, in a frenzy of despair, he committed suicide.

At necropsy, metastatic nodules were found in the liver, pancreas, spleen and peritoneum of the transverse colon. There was infiltration of the lymph nodes of the mesentery of the small intestine and also of the perigastric, peripancreatic and pericolic lymph nodes. Nodules as large as hen's eggs were scattered throughout the liver, and the fatty capsule of the liver was infiltrated with neoplastic plugs. There was no invasion of the kidneys, suprarenal bodies or ureters, and the only vesical lesion was the presence of two superficial ulcerations of its mucosa on the posterior wall. The prostate, rectum, testes or vasa deferentia did not suffer in any way.

Behind the bladder, however, between it and the rectum, was a large round, whitish mass, the size of an infant's head invested with peritoneum and surrounded with other smaller nodules of the same character. On incision of the retrovesical peritoneum the mass was seen to be a part of the right seminal vesicle and ampulla. These, when cut, had an almost triangular shape with two distinct surfaces: an anterior or vesical surface, which looked normal and nearly flat and

46. Pelagatti, V.: Adeno-carcinoma della vescichetta seminale destra, Arch. ital. di urol. **11**:201 (Feb.) 1934.

which was not related to the tumor, and a posterior surface, which was folded in an angle with the vertex inward, becoming fused in the neoplastic mass. The lumen of both the seminal vesicle and the ampulla were, however, conserved and only slightly reduced. There were no changes in the left vesicles and ampulla. The prostate seemed rather small and was not involved in the mass.

The pathologic changes in the right ampulla were only slight and were chiefly the result of compression. Only at the vertex of its posterior surface were the muscularis and adventitia thickened and continuous in an indistinct way with the stroma of the tumor. The mucosa of the right seminal vesicle revealed a riotous proliferation of epithelial cells, especially in the posterior part, where no special structure was any longer discernible. In places not even the stroma supporting the mucosa could be recognized; there was only a great quantity of chaotic epithelial cells forming a sort of cord or plug leading into and becoming confused with the parenchyma of the tumor. Beyond the seminal vesicle the structure of the tumor was more glistening, with irregular trabeculae of collagenous fibers, which were ramified extraordinarily. The metastasis to the liver and lymph nodes faithfully reproduced the carcinomatous structure of the primary tumor. There was evidence that the metastasis was mostly by way of the lymphatics, but metastasis by the blood stream cannot be excluded, since there was manifest neoplastic infiltration of the walls of the newly formed vessels.

URINARY CALCULI

Thomas [47] stated that India may be looked on as the home of urinary calculi. Urinary calculus is one of the commonest conditions with which a surgeon is called on to deal. Two hundred and fifty cases were handled in a period of six years in a part of India in which this condition is very prevalent. The greater number of the patients were males who were more than 8 years of age. It was, however, a common thing to operate on much younger children. The youngest child was 6 months old and had a stone the size of a hazelnut. The proportion of females was small, and those operated on were chiefly below the age of puberty. The reason for this is obviously the ease with which small stones can be passed through the female urethra. Two or three cases of stone in the prolapsed bladder occurred among patients who had procidentia, the stones being removed through the anterior vaginal wall. A good many stones impacted in the male urethra were dealt with, the greater number being held up at the commencement of the penile urethra.

47. Thomas, R. C.: Stone in the Lower Urinary Tract in India: Examples of Multiple Calculi, Lancet **2**:193 (July 28) 1934.

A small number of prostatic stones were encountered. The most common stone was the hard, smooth, oval uratic stone; two of these were often found and sometimes three. Next came the phosphatic stone. Both of these types were often very large. The mulberry calculus was always small, as the patient sought advice early because of the pain and vesical irritability it caused. Hematuria and pain at the end of micturition were the usual symptoms in cases of mulberry calculus. The other patients complained more of frequency, sudden cessation of the urinary flow and a feeling of heaviness in the perineum. Pain became a predominant symptom only when cystitis was present or when a stone became impacted in the prostatic urethra. Thomas stated that a striking thing about most of the cases was the long time during which symptoms had been endured before advice had been sought. Some of the adults, judging by the size of the stones, must have suffered for years. This was borne out by the multiplicity of stones in some cases. In several cases of long standing drainage of the bladder was necessary on account of the pronounced degree of cystitis. Thomas removed every stone by the suprapubic route except those in the prolapsed bladder and the impacted urethral stones. Many of the stones were very large and therefore not suitable for lithotrity. Many patients had two and even three stones, and lithotrity would have been a long operation. Cystitis was very common. The removal of a stone or stones by the suprapubic route never required more than twenty minutes, thus saving valuable time, and often it was completed in ten minutes. There appeared to be no more risk with the suprapubic operation than with lithotrity. The suprapubic operation had the added advantage of permitting direct inspection of the vesical wall. The average time spent by the patient in the hospital was fifteen days. In India, time is of little account. All patients received a mixture of methenamine and acid sodium phosphate, 10 grains (0.65 Gm.) each, for three days, and the stones were removed on the fourth day. The operative technic consisted of the usual subumbilical incision and separation of the rectus abdominis and pyramidalis muscles, which were retracted by an assistant. The peritoneum was then wiped upward off the bladder, which was opened below it. After removal of the calculus, the bladder was swabbed dry and then closed from above downward with a running suture of no. 0 catgut, which included both mucous membrane and muscle. After this suture had been tied below, it was brought up again as an invaginating suture and tied with the original end. The fascia was closed with no. 1 catgut in children and no. 2 catgut in adults. The skin was closed with clips. A catheter was passed and secured in the usual way and retained for from nine to ten days.

Colby [48] stated that the fundamental problem in the consideration of urinary calculi is the prevention of recurrence. The importance of this statement is borne out by reports from the great clinics of the country of recurrences in from 20 to 40 per cent of the cases of nephrolithiasis. He emphasized the fact that stone in the kidney as well as stone in the bladder may be a sign of hyperfunction of the parathyroid glands rather than a primary urologic disease. The question of the formation of calculi is complex, and many factors must be considered. The urine itself presents the extraordinary phenomenon of an extremely supersaturated solution which does not obey the ordinary laws of chemical solutions. Substances excreted by the kidneys are but slightly soluble in water, for instance, uric acid and calcium oxalate; uric acid is from ten to twenty times more soluble in urine than in water. The ability of the urine to hold these salts in solution is said to be the result of the presence in the urine of protective colloids. They prevent the precipitation of the salts and inhibit the formation of calculi. If the colloids are deficient in amount, or if their action is interfered with by chemical changes, such as occur in stagnant urine, the protective mechanism is lacking, and the excess of free salts is precipitated as calculi. By feeding oxamide to rabbits and dogs, Keyser demonstrated that a marked increase in the crystalline content of the urine at times apparently so adds to the burden put on the colloids that they are unable to perform their protective action. Formation of calculi in the urinary tract is the result of an abnormal precipitation of the crystalline elements normally present in urine. There is much evidence to show that obstruction plays an important part in the formation of calculi, and all investigators regard urinary stasis as fertile soil for the subsequent formation of stones. The importance of infection as a cause of calculi is difficult to evaluate. Many stones develop in uninfected urine, and in many instances of long-standing sepsis calculi never occur. Urea-splitting organisms may cause rapid incrustations in the kidney and bladder. Diets deficient in vitamin A, if given for some time, cause crystalline deposits in the urinary tract of laboratory animals. The geographic incidence of stone, as in India and China, seems to be the result, in part at least, of dietary deficiency.

It has been proved that the parathyroid glands affect calcium metabolism. Total extirpation of these glands causes a decrease in the level of serum calcium and results in tetany. Tumors of the parathyroid glands cause marked metabolic changes with a loss of bone calcium, elevation of the level of serum calcium and an increase in the urinary output of calcium. The resulting bony changes, decalcification, cysts,

48. Colby, F. H.: Urinary Calculi Associated with Parathyroid Disease, Surg., Gynec. & Obst. **59**:210 (Aug.) 1934.

benign giant cell tumors and spontaneous fractures, characterize the condition known as generalized osteitis fibrosa. The frequency with which stones occur in this disease is more than a coincidence.

In 28 cases of generalized osteitis fibrosa (Rankin), renal calculi were present in 5, and in 4 other cases in which tumors of the parathyroid glands were removed renal stones were present. The pouring out of calcium through the urinary tract seems to result in the formation of calculi in many patients with hyperparathyroidism. Urinary stasis is probably an important contributing factor in this condition. Tumors of the parathyroid glands have been removed from 13 patients at the Massachusetts General Hospital. In 8, or 61 per cent, demonstrable calcification was present in the urinary tract. Three had bilateral renal stones. The patients on presentation gave the usual history of renal colic, hematuria and other signs typical of stone in the kidney and without the usual symptoms of generalized osteitis fibrosa. The true condition in these patients was recognized by discovering a high serum calcium and a low serum phosphorus content. The output of calcium in the urine was increased and the output of phosphorus was decreased. Colby emphasized that while generalized osteitis fibrosa is frequently accompanied by urolithiasis it is important to recognize that calculi often form in the urinary tract without any of the bony changes which characterize this disease, although tumors of the parathyroid glands are present and constitute the underlying cause of the urolithiasis. Unless the tumor is removed the stones will frequently recur.

Keyser [49] cited the following facts as evidence that a metabolic disturbance may cause urinary calculi: 1. Calcium phosphate calculi developed in rats which were fed a diet that was deficient in vitamin A. 2. "Intensely excessive excretion of normal urinary crystalloids produces stone formation." Keyser and other investigators have demonstrated that artificially produced excessive oxaluria will cause urinary calculi under aseptic conditions. 3. "Crystalloids normally foreign to the urinary tract excreted therein by metabolic perversion are often found clinically as calculi." Keyser previously demonstrated that asceptic calculosis of this type could be produced by feeding oxamide. 4. "Colloids normally absent in the urine when they do find entrance may give rise to stone formation." The fibrin calculus, which is composed of alternating layers of calcium phosphate and fibrin, and calculi which are composed of cystine, xanthine, indigo and urostealith, are examples of this type of calculosis.

The evidence of specific infection as another cause of calculosis is presented. To the experimental work of Rosenow and Meisser with

49. Keyser, L. D.: The Relationship of Urinary Infections to Recurrent Calculi, J. Urol. **31**:219 (Feb.) 1934.

streptococci and of Hager and Magath with Bacillus proteus-ammoniae, Keyser adds instances of experimental infectious calculosis in rabbits produced by vesical inoculation with strains of streptococci from 2 patients who had calculi. A review of the mechanism of the experimental formation of stones discloses that hyperexcretory calculosis is dependent on the modification of urinary crystals by the urinary colloids from isolated units to coalescent, spherical units. When such fusing spherical units are precipitated simultaneously with the jellying of irreversible urinary colloids to form the organic framework, the formation of stones takes place. Calculosis from infection seems to arise from ulcerative lesions of the urinary epithelium and subsequent impregnation of this epithelium by lime salts.

Twenty-eight cases of recurrent urinary calculi were reviewed in detail. In 16 personal cases, almost all cases of alkaline earth stones with infection, Keyser has been able to break the cycle of recurrence by removal of existing calculi, by acidifying the urine with diet and drugs, by removal of focal infections and by repeated cystoscopic lavage and ureteral dilation to promote better drainage. In most instances this therapy has resulted in clearing up the urinary infection as well as in preventing the recurrence of calculi.

UROGRAPHY

Campbell [50] reported his observations in 381 intravenous urographic studies of 304 infants and children; in this study almost 1,900 urograms were analyzed. Two of the patients were 3 weeks old, and 2 others were 4 weeks old. There were 182 females and 122 males. Campbell employed the method in children for assistance in the diagnosis of chronic pyuria, of hematuria which was not the result of nephritis, of tumor or pain in or along the upper urinary tract and, in some instances, of disturbances of urination not falling under the foregoing groupings. Parenthetically, in practically every case in which a child has an abnormal excretory urogram or in which the results of ureteral catheterization suggest disease of the upper part of the urinary tract, a retrograde pyelogram should be made. Using the intravenous urographic mediums for instillation through a catheter, Campbell did not hesitate to perform bilateral retrograde pyelography. Retrograde urography was employed in all but 36 of the 304 cases and serves as a check on the intravenous method. Intravenous urography is particularly indicated in those cases in which ureteral catheterization is impossible or is refused or in which the condition of the patient does not warrant instrumentation. Campbell stated that this type of urog-

50. Campbell, M. F.: Intravenous Urography in Infants and Children: Observations in 304 Cases, J. Urol. **32**:55 (July) 1934.

raphy is said to be contraindicated by severe renal or hepatic deficiency, idiosyncrasy to iodine, thyrotoxicosis, active pulmonary tuberculosis and exudative diathesis in children. Campbell used iopax 19 times, neo-iopax 8 times, skiodan 7 times, and diodrast 347 times. Iopax and skiodan are disadvantageous to inject because of the relatively large fluid bulk required; in highly nervous or unruly children this is a real disadvantage. Because of its freedom from irritating effect, as manifested by absence of pain in the arm on injection, and its minimal toxicity, rapid excretion and satisfactory concentration, Campbell preferred diodrast, particularly in children. The amount of solution required for children is relatively much greater than for adults. The average doses which Campbell employed for children were as follows (given in per cent of the adult dose): under 6 months of age, 25 to 30 per cent; 7 to 12 months, 30 to 35 per cent; 1 to 3 years, 35 to 50 per cent; 4 to 6 years, 50 to 80 per cent, and 7 to 8 years, 80 to 100 per cent. The child should be spared purging enemas until the return is clear, and starvation. Yet for constipated children a small dose of castor oil and a low enema to clear out the rectum are sometimes advantageous. No meal should be omitted; the longer the interval from the last meal, the greater will be the gaseous distention of the intestine. Greatly reducing the fluid intake for from twelve to eighteen hours before examination considerably increases the concentration of the excreted medium in the urine and thereby favors better urographic definition. For older children the injection is usually given into one of the cubital veins; for infants with fat arms and delicate vessels one may be forced to employ a superficial vein elsewhere (the wrist, the back of the hand, the feet or the scalp), the external jugular vein or, as Campbell did in 1 case, the fontanel. The injection should take at least two minutes; employment of a fine needle will control any tendency to too rapid injection. The conventional roentgenologic diaphragm can be used only for older cooperative children. For all others shorter exposures (from one sixteenth to one eighth of a second) must be employed. With the latter group, the roentgenologist must exert unusual patience and cooperation to make the exposure in the fraction of a second when the child is still; this is usually at one of the extremes of respiration and preferably at full expiration. As a rule, the interval between exposures is considerably less for children than for adults. The following schedule will be found satisfactory for most children: (1) flat roentgenograms made before intravenous injection; (2) injections of the radiopaque medium, and (3) roentgenograms made five, ten and fifteen minutes after the completion of the injection. The immediate development of the early roentgenograms will indicate whether longer or shorter intervals between exposures

will be advantageous; in some instances subsequent roentgenograms at intervals of an hour or more may be indicated.

Abeshouse [51] stated that the phenomenon of pyelolymphatic backflow can be graphically demonstrated by injection of the renal and perirenal lymphatics during pyelography. It was his opinion that injection of these lymphatics is the result of the easy penetration of pyelographic medium into anomalous renal lymphatics, which may be congenital or acquired. The presence of this type of anomalous renal lymphatics has not been demonstrated; this may be the result of the scant knowledge of the normal anatomy and physiology of the renal lymphatics, of dearth of pathologic specimens showing such changes and of the technical difficulties encountered in injecting normal and pathologic renal lymphatics. Overdistention of the renal pelvis and excessive pressure at the time of pyelography play no rôle in the production of injected renal or perirenal lymphatics. Abeshouse strongly emphasized the dire need of further investigation of the anatomy and physiology of the renal lymphatics and the necessity for careful pyelographic studies in cases of parasitic and nonparasitic chyluria of renal origin in order to demonstrate the exact point of communication between the lymphatic and the urinary system and to enhance the knowledge of the renal lymphatics.

ANESTHESIA

Spinal Anesthesia.—Spinal anesthesia, as employed by Howley and Robertson,[52] is comparatively safe and is usually preferred to general anesthesia in the urologic service at the Bellevue Hospital. In six years, spinal anesthesia was used in 1,490 cases. Two deaths were reported to have occurred in cases in which spinal anesthesia was employed; both patients presented a poor risk and were more than 70 years old. Patients who have hypotension or hypertension, with cardiovascular injury, present the poorest risks. Spinal anesthesia is not advisable for children or for apprehensive patients. Nupercaine (1:200) is best suited for long operations and procaine crystals are best for short procedures. A comparison between the results obtained in two periods of six years has been made from the same service with the same type of cases and practically the same attending staff. In one of these periods, which started in 1919, general anethesia was used (gas-oxygen and gas-

51. Abeshouse, B. S.: Pyelographic Injection of the Perirenal Lymphatics: Report of Two Cases and Review of the Literature; Consideration of the Relation of Pyelolymphatic Backflow to Chyluria, the Anatomy of the Lymphatics of the Kidney and the Mechanism of Backflow from the Renal Parenchyma and Pelvis, Am. J. Surg. **25**:427 (Sept.) 1934.

52. Howley, T. F., and Robertson, J. P.: Spinal Anesthesia: Report of 1,490 Cases, Am. J. Surg. **24**:129 (April) 1934.

oxygen-ether) in 1,094 cases with postoperative death in 164, or 15 per cent. In the other period, which started in 1925, spinal anesthesia was used in a total of 1,490 cases, with postoperative death in 149, or 10 per cent. Although no attempt was made to prove anything, Howley and Robertson expressed the belief that the comparison is significant when one considers that each group of observations was from the same service with practically the same visiting staff and with the same type of cases.

PNEUMATURIA

Mulsow and Gillies [53] stated that pneumaturia without a fistula between the bladder and the intestinal tract is rare. The primary type of pneumaturia appears to be so rare and the condition persists for such a short time that few cases have been studied with any degree of completeness. The organisms which have been described in these cases have in all instances belonged to the colon group of bacteria. In the case reported by Mulsow and Gillies, Nocardia would not produce gas in urine or any of the ordinary carbohydrate culture mediums. It probably did not produce gas but was the only organism able to survive for any length of time in the strongly alkaline urine. None of the bacteria found in cases of pneumaturia has consistently produced gas in urine which was free from dextrose. Obstruction in the urinary tract, together with marked atony of the muscles of the bladder, has been found in most cases. In these cases there is often considerable residual urine and infection. In the case which was reported by Mulsow and Gillies it appears that the gas was formed either by the acid urine from the kidneys, which acted on the alkaline carbonates of the urine retained in the bladder, or by some organism which was killed by the strongly alkaline urine. The fact that no more gas was formed after the patient was placed on a diet for relief of ulcer and given alkalis suggests that the pneumaturia may have resulted from the action of the acids in the urine as it came from the kidneys. Other patients whose cases have been reported in the literature have recovered spontaneously or have been cured by simple rest in bed, antiseptic irrigations of the bladder and drainage of an infected kidney.

PRESACRAL SYMPATHECTOMY

McCrea and Macdonald [54] said that the functions of the autonomic nervous system are even now only beginning to be understood and that the knowledge of the nervous control of the bladder is incomplete.

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53. Mulsow, F. W., and Gillies, C. L.: Primary Pneumaturia, with Report of a Case, J. Urol. **32**:161 (Aug.) 1934.

54. McCrea, E. D., and Macdonald, A. D.: Presacral Sympathectomy and the Urinary Bladder, Brit. J. Urol. **6**:119 (June) 1934.

Therefore, they warned against the too enthusiastic practice of presacral sympathectomy, because the indications for, and the results to be expected from, this procedure are not yet defined.

A vast amount of experimental work on animals has been done on the functions of the hypogastric nerves, which was summarized by Dennig in 1926. Since that time a number of observations on man have added to the knowledge acquired by the experimental physiologist. The authors have demonstrated that in the cat and the dog the effect of stimulation of any nerve trunk on intravesical pressure is conditioned by the muscle tonus and the nature and depth of the anesthesia and the bladder is inhibited by stimulation of the hypogastric nerves when in tone and showing rhythmic contractions. On decentralizing the viscus by spinal anesthesia, the inhibitor response is replaced by contraction. McCrea and Macdonald concluded that the hypogastric nerves contain both inhibitor and excitor fibers and that it has been too generally accepted that the sympathetic nerves of the bladder are purely inhibitors and the parasympathetic nerves are excitors.

On section of the hypogastric nerves in the dog it has been found that the bladder functions normally. When all the nerves but the hypogastric were divided, overdistention was still appreciated. Hyperemia also occurs as an effect of section of the presacral nerves, and pain is produced by stimulation of its central cut end.

The results of section of these nerves on the normal bladder of human beings are well known and do not differ from those noted in the bladder of animals. Micturition, thereafter, is absolutely normal, apart from occasional instances of slightly increased frequency. These nerves are not essential to a satisfactorily acting bladder. A number of observations have been made of the effect of section on the pathologic states of the bladder. The presacral nerve has been resected to relieve pain in cases of chronic cystitis, tuberculous cystitis, ulceration and "cystalgia." Pain can be partially but not completely controlled, and rebellious inflammations are sometimes cured, perhaps as suggested by Learmonth, because of vasodilatation.

The operation has been performed to relieve the retention of "cord bladder" in which it is assumed that the malfunction of the pelvic nerves results in unbalanced control of the hypogastric nerves. Improvement has been noted.

The authors concluded that the sympathetic and parasympathetic nerves function together in the regulation of the bladder but that the parasympathetic nerves, through the pelvic nerves, are by far the more important. While one or the other group may be the dominant excitors or inhibitors, yet it is not to be assumed that either is exclusively so or yet that they are antagonists. Both transmit sensory impulses, the

pathway of the pelvic nerves being the more important. The precise action of the hypogastric nerves on the vesical sphincter is unknown; in fact, they may not influence it at all.

UROGENITAL INFECTION

Walther and Willoughby,[55] who have had seven years of experience with azo dyes, found them of definite value in combating urogenital infections. These drugs, especially pyridium, have proved superior to the older urinary antiseptics in common use and are practically harmless in their action. They have a wider field of usefulness by acting equally well in alkaline or acid urine; they are synergistic to most other remedies and require no special dietary regimen. Nothwithstanding the great practical value of combined clinical and laboratory research, Walther and Willoughby believed that there would remain much in the empirical inheritance of the dyes which would not be fully explained by present-day investigation.

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55. Walther, H. W. E., and Willoughby, R. M.: Oral Dye Therapy in Urogenital Infections, Am. J. Surg. **25**:460 (Sept.) 1934.

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